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AN ELECTRIC INTERURBAN RAILWAY using alternating-current motors and designed to carry both passenger and freight traffic is to be built from Lansing, Mich., to St. Johns, Alma and St. Louis, Mich., a total distance of 60 miles. It is now in operation, but as a steam line temporarily, from Lansing to St. Johns, 20 miles. The right of way was at first secured along the public highways, but this policy was afterwards abandoned and land was purchased for a right of way 66 ft. wide. The line runs through a good farming country, suitable for the raising of beets for the new beet-sugar factory at Lansing, and it is expected that this, together with the supply of milk for a condensed milk factory, will furnish considerable traffic to the railway. All bridge structures are pile trestles. The heaviest cut is near De Witt, 2,000 ft. long and 13 ft. deep, in yellow clay. About three miles north of De Witt a sink-hole was encountered, which absorbed a great amount of filling before a solid bank was finally built. Several marshes are crossed by filling, but at Long Hair marsh, between De Witt and St. Johns, the grade had to be changed and a plank platform built to carry the roadbed. The sharpest curve has a radius of about 1,320 ft. The alternating current from the power station will be transmitted direct to the trolley wire, and alternating-current motors used on the cars. These motors are now being built to the special designs of Mr. B. J. Arnold. The road is known as the Lansing, St. Johns & St. Louis Electric Ry., and the contract for the complete construction and equipment was taken by the Arnold Electric Power Station Co., of Chicago.

AN ELECTRIC INTERURBAN RAILWAY is being built between the cities of Seattle and Tacoma, Wash. When completed it will be 35 miles long, running through a well-populated district; it will be operated by trolley within the city limits, and by third rail in the open country. The road, by the terms of its franchise, must be in operation connecting the cities of Seattle and Tacoma by Jan. 1, 1903, and it is expected that this condition will be fulfilled in spite of the fact that numerous engineering difficulties are being encountered. The portion within the city limits of Seattle is now practically completed; this portion of the road crosses low-lying tide-flats, and the roadbed had to be elevated on piles. Some of the provisions of the franchise granted to the road by the city of Seattle are worthy of mention. The poles for the trolley wire must be metal within the limits of Seattle, and the council reserves the right to require the road to change to underground conductors when the public convenience may require this, and when it shall also compel any similar road to do so. Any municipal wires may be attached to the poles of the company. The return of the line-current along the company's own metallic conductors must be insured sufficiently to prevent any damage to city property from such currents. The crossings with steam roads may be at grade for the present, but when the city so requires the electric road must elevate its tracks so as to pass above them. Transfers shall be issued to all city lines, school children shall be carried for half fare, and city officials shall be carried free of charge. Two per cent. of the gross receipts of the road shall annually be paid into the city treasury. The pavement between the tracks and for 1½ ft. on either side shall be laid and maintained by the company, to be the same as the city's pavement on the remaining width of the street. In addition to this, the company must construct and maintain a bridge over which the line will run, and must construct and operate a drawspan across the channel when so required by the Government.

THE JERSEY CITY & NEW YORK RAILWAY CO., which proposes to complete the old North River Tunnel, is said to have secured as a New York terminal the greater part of the block bounded by Tenth, Hudson, Greenwich and Christopher Sts. The purchase was made through Horace S. Ely & Co. It is also reported that Mr. Charles M. Jacobs, the Engineer of the proposed Pennsylvania Ry. tunnel under the same river, is to be Engineer for the Jersey City & New York tunnel as well.

THE PROPOSED CONSTANTINOPLE-BAGDAD RAILway, for which the German and French bondholders obtained a concession on Dec. 23, 1899, is fully surveyed, but construction halts. The necessary capital was estimated at $87,500,000, of which the Germans were to raise 60% and the French 40%. But it was later stipulated that a Turkish guarantee of not less than $6,000,000 per year was advisable. This sum the Porte could only raise by obtaining the consent of the powers to increase its customs duties from 8% to 11%. While the Germans have been endeavoring for two years to have the powers consent, England—for commercial, and Russia—for political reasons, hold out against it. Russia objects because such a railway would open up the wheat fields of Mesopotamia, to the detriment of Russian wheat; it would compete with the Siberian and Tashkend railways, and would interfere with the already irregular payment of the Russian war indemnity due from Turkey.

THE ST. LAWRENCE & GREAT LAKES Transportation Co. is to build and operate a steamship line to connect the Great Lakes with tidewater at Quebec. The American Shipbuilding Co., of Cleveland, O., is building for this purpose two freighters, each 236 ft. long, 42 ft. beam and 4,000 tons cargo capacity; or 3,000 tons capacity on 14 ft. in the Canadian canals. They will be equipped with triple-expansion engines and Babcock & Wilcox marine boilers, and cost about $200,000 each.

ELECTRIC TIDE INDICATORS are being installed at various places by the U. S. Coast and Geodetic Survey. One lately placed in the Philadelphia Maritime Exchange shows the exact stage and character of the tide in the harbor, and indicates whether the tide is rising or falling. This tide indicator was designed by Dr. G. Hasler, of Berne, Switzerland, but it has been supplemented by an important device by Mr. E. G. Fischer, Chief of the Instrumental Division of the U. S. Coast and Geodetic Survey. For several years past large tide indicators have been installed in the harbors of New York, Philadelphia and San Francisco. These have dials nearly 30 ft. in diameter, and the figures and divisions on them can be distinguished several miles away. In these indicators the movement of the arms is directly controlled by the change in water level. The electric tide indicator referred to is described and illustrated by Mr. L. Y. Schermerhorn, M. Am. Soc. C. E., in the "Proceedings of The Engineers' Club of Philadelphia" for January, 1902.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Choctaw, Oklahoma & Gulf Ry. near Little Rock, Ark., on the morning of Feb. 14. A large mass of rock rolled down the steep bank of the Arkansas River, along which the line runs, and fell upon the caboose of a passing work train. Seven men are reported killed and many injured.——Four men were killed in a butting collision on the Iowa Central Ry., near Gifford, Ia., on Feb. 16. A northbound engine running light ran into a southbound passenger train; the engineer and fireman on both engines lost their lives.——On Feb. 14, the second section of an eastbound freight on the Pennsylvania R. R. ran away, above the Horseshoe curve, west of Altoona, and crashed into the rear end of the first section. Three men were killed outright and several received injuries which will probably prove fatal.——Two men were killed in either of two freight wrecks in different sections of the country during the past week. On Feb. 11 a freight on the Chicago, St. Paul, Minneapolis & Omaha Ry. ran into a hand car on the bridge over Lake St. Croix at Hudson, Wis.; two men were killed. On Feb. 12 a rear collision of two freight trains on the Seaboard Air Line occurred near Raleigh, N. C.; two men in the caboose of the forward train were burned to death.

A DESTRUCTIVE EARTHQUAKE is reported from the Baku district in Russia. According to the meager information available at present, from one to two thousand persons were killed. The earthquake apparently centered near the city of Shemakha, some 60 miles west of Baku, in Transcaucasia.

AS A RESULT OF THE DYNAMITE EXPLOSION of Jan. 29 in the New York Rapid Transit Railway, the Grand Jury has returned seven indictments, four for manslaughter in the first degree. These four include Ira A. Shaler, M. Am. Soc. C. E., sub-contractor for that section of the tunnel; Ernest G. Matheson, Civil Engineer under Mr. Shaler; Joseph Bracken, foreman; Moses Epps, powderman in charge of the exploded magazine. All of these were indicted for illegal storage of explosives. The other three were Charles E. Fraser, Civil Engineer under Mr. Shaler; George E. Murray, Superintendent of the Bureau of Combustibles in the Fire Department, and Samuel Wesley Smith, M. D., Inspector under Mr. Murray. The last two were charged with neglect of duty, and Mr. Fraser for illegal storage of explosives. The full reasons for these findings are not given, and the press comments upon them rather severely. The question has been raised whether the Rapid Transit Act does not overrule the Fire Department regulations and permit the subway contractors to have on hand each day the amount of dynamite needed for that day. Corporation Counsel Rives has declined to give an opinion on this point, and will leave it for the courts to decide. The above verdicts were rendered on the theory that the Fire Commissioner's authority was final.

ORDINANCES REGULATING THE USE OF EXPLOsives in New York city are to be drafted by a commission of experts appointed by Mayor Low. The commission consists of the following members: Gen. G. C. Eaton, U. S. A., retired; Mr. Wm. Barclay Parsons, M. Am. Soc. C. E.; Thomas Sturgis, Fire Commissioner; J. A. Haskill, President Repano Chemical Co., and Prof. Charles T. McKenna, chemical expert. The commission will draft ordinances to be acted upon by the Board of Aldermen.

TWO OF THE THREE "FIREPROOF" buildings in the burned district of Paterson, N. J., stood the test, though surrounded by burning buildings. The new City Hall, which was classed as fireproof, was completely burned out inside as to its woodwork, leaving the walls, roof and tower standing. The Second National Bank was separated from the City Hall by a 25-ft. street. It was fiercely attacked on three sides by the flames and the fire caught in the roof, worked down the elevator shaft to the cellar and then entered the directors' room, on the second floor. But, though not a drop of water was thrown on this building, it withstood the flames for six hours, damaging only the top floor and elevator shaft. Not an office in the five lower stories was touched. The Paterson Savings Institution caught fire in the roof, spread very slowly, and the two upper stories alone were damaged; but the flames died out when the adjoining structures fell. The three buildings named had steel frames and tile floors, woodwork being confined to the doors, windows and floors of the rooms. In the corridors the floor was tile or cement. The white marble of which the Second National Bank was built was neither defaced or injured, but the Indiana limestone in the City Hall soon cracked away about the doors and windows under the heat. The Belleville graystone in the walls of the St. Joseph Church withstood the flames, though the interior was completely burned out.

BIDS FOR 10,000 WATER METERS at Columbus, O., in sizes ranging from ⅝-in. to 4 ins., were received a few days ago. For 6,000 ⅝-in. meters the Thompson Meter Co., of Brooklyn, N. Y., bid $6.30 each, while for 3,500 ¾-in. the Pittsburg Meter Co., of East Pittsburg, Pa., bid $9.40 each. The bids in detail were given on p. 60 of the supplement to our issue of Feb. 13. The contract has been divided between the Hersey, Thompson, Pittsburg and Neptune companies, but there is talk of litigation. Consumers must buy the meters from the city at a slight advance over the contract prices. No one will be compelled to use meters, but doubling the present schedule or fixture rates is proposed.

MUNICIPAL OWNERSHIP OF WATER-WORKS at Los Angeles, Cal., has been secured after years of agitation. The works were built by the city in 1862 and leased to three men in 1868. These men organized a company, which rebuilt and extended the works. The city has now secured the property of the Los Angeles City Water Co. and of two companies subsidiary to it for $2,000,000. The lease of 1868 was for three years, and provided that on resuming possession of the works the city should pay for the improvements made to date.

THE MARCONI WIRELESS TELEGRAPH apparatus on Feb. 1 successfully transmitted messages at a distance of 150 miles between the steamship "Philadelphia" and the wireless telegraph station at the Lizard, on the English coast.

THE CINCINNATI SOUTHERN RY. AND ITS IMPROVEMENTS.

HISTORY.

The Cincinnati Southern Ry. is of peculiar interest historically in that it is a municipally owned line, having been promoted and built by the city of Cincinnati, O., and being still owned by that city. The road was projected soon after the close of the Civil War, for the purpose of connecting Cincinnati with Chattanooga, to connect with the Southern systems of railways, and to develop trade with the Southern industries. The road was built by the city of Cincinnati under the direction of a Board of Trustees, appointed by the Superior Court of the city, an act authorizing this having been passed by the General Assembly of the State of Ohio in 1869. The board was composed of five members, who hold office for life. The total cost of the railway was $18,500,000, and the city raised the funds for construction by the issue of municipal bonds, which are retired year by year, the last being retirable in 1911.

The road extends from Cincinnati, O., to Chattanooga, Tenn., 336 miles, and a map of the route is shown in Fig. 1. Surveys were commenced in 1869, the first contract (including the "Kings Mountain tunnel) was let in 1873, and the road was completed in February, 1880. Trains were run through from Cincinnati to Somerset in 1877, and to Chattanooga on Feb. 22, 1880. In 1881, the road was leased to the Cincinnati, New Orleans & Texas Pacific Ry. Co. for a term of 25 years, divided into five-year periods, with an annual rental of $800,000 for the first period, $900,000 for the second, $1,000,000 for the third, $1,090,000 for the fourth, and $1,250,000 for the fifth. The lessee company was also to pay $12,000 per year for the expenses of the Board of Trustees. In 1893, the C., N. O. & T. P. Ry. Co. was placed in the hands of a receiver, and in 1895 a controlling interest in the capital stock of that company was acquired by the Southern Ry. Co. and the Cincinnati, Hamilton & Dayton Ry. Co., which interests (in 1896) made a bid to the Board of Trustees for a perpetual lease (with the privilege of purchase in 1996) of the Cincinnati & Southern Ry., but this offer was rejected by popular vote of the city. The receivership was terminated in 1899.

As the present lease expires in 1906, the lessee company has naturally not been inclined to make large expenditures recently in general improvements, but nevertheless some important improvements have been made and the road has been kept in excellent physical condition. It is recognized that 25 years is too short a term for a railway lease, and the company has made propositions for an extension of the lease for 60 years, with some modification of the terms. As the railway is the property of the city, this proposition had to be submitted to popular vote, and the vote was taken on Nov. 7, 1901. Of 68,495 votes cast, there were 47,486 in favor of and 15,168 votes opposed to the extension and modification of the lease; while 45,658 votes were in favor of and 14,603 votes opposed to the issue of bonds for new terminals. This means that both propositions are approved by the city, but the question has yet to be passed upon by the courts, whose decision is expected to be rendered early in the spring.

Under the terms of the new lease, the time is extended for 60 years from the expiration of the present lease, or to Oct. 12, 1966. The Cincinnati, New Orleans & Texas Pacific Ry. will increase its capital stock by $2,000,000, making a total of $5,000,000, and will pay an annual rental of $1,050,000 to the city (in quarterly payments) for the first 20 years from 1906, $1,100,000 per annum for the next 20 years, and $1,200,000 per annum for the remainder of the term of the lease. The city, on its part, undertakes to borrow $2,500,000 on city bonds, as a fund for terminal facilities and permanent improvements of the railway, the company paying the interest charges on these bonds as an additional rental, plus 1% per annum as a redemption fund. The bonds are not to be issued for a greater amount than $500,000 in any one year.

CONSTRUCTION.

The surveys and construction work were carried out with great care and ability; first-class structures were built and good methods of construction employed. A good location was obtained, very few changes being practicable to improve the alinement or profile for modern conditions of operating. The principal change is a diversion about 1.65 miles long recently completed near Emory Gap, Tenn., to avoid a long tunnel on the line, which would require expensive arching to replace the present timber lining. This work is described further on. The original work was done under very complete specifications, and the annual reports issued by the Chief Engineer during the construction of the work give much valuable and

Fig. 1. Map of the Cincinnati Southern Ry.
W. J. Murphy, General Manager.
G. B. Nicholson, M. Am. Soc. C. E., Chief Engineer.

interesting information regarding the execution of the various parts. The present chief engineer has in his possession the original plans (with contours and land lines), and the original field-books in which the progress of the work, the materials encountered, and other matters, are recorded very completely and faithfully. In fact, by the aid of these maps and note-books it is often practicable to decide upon the location of spur tracks desired, and to estimate their cost. For the right-of-way records, the maps have been traced on separate sheets bound together in large volumes, and on these sheets the changes, records, etc., are marked from time to time. Bridge records are kept in ruled books, with one or two bridges to a page. In these are entered descriptions of the structures, their floor systems and other details, and all records of maintenance and repair work are entered up, with details of cost.

The road has had only four chief engineers: W. A. Gunn, 1869-1873; Thomas D. Lovett, M. Am. Soc. C. E., 1873-1876; G. Bouscaren, M. Am. Soc. C. E., 1876-1885; and George B. Nicholson, M. Am. Soc. C. E., from 1885 until the present time. The Cincinnati Southern Ry. was a training school for a number of engineers who have obtained eminence in their profession. Mr. Samuel M. Felton, M. Am. Soc. C. E., was Receiver for the C., N. O. & T. P. Ry., during the most critical parts of its troubles, and did much to improve the operation and the physical condition of the road, while introducing many economies in the management.

GENERAL DESCRIPTION.

The Cincinnati Southern Ry. extends from Cincinnati, O., to Chattanooga, Tenn., a distance of 336 miles, the line being single track, with about 151 miles of sidings. From the Central Union Station in Cincinnati, it uses the tracks of the Baltimore & Ohio Southwestern R. R. and the Cleveland, Cincinnati, Chicago & St. Louis Ry., for about two miles (making a total of 338 miles between terminals), and after passing under the approach to the Ohio River bridge the line describes a complete circle through the western part of the city in order to rise from the elevation of the terminal to that of the bridge. The line has a number of long and heavy grades which try the capacity of the engines with heavy trains. The maximum grades are as follows: North approach to Ohio River bridge, 1.5%; Ludlow to Erlanger, 1.14%; Erlanger to Lexington, 0.5%; Lexington to Cedar Grove, 1%; Cedar Grove to Oakdale, 1.14%; Oakdale to Chattanooga, 0.75%. The sharpest curves are of 6°, and these occur on uearly all the divisions, while several of the tunnels and viaducts are built on these curves. The grades are not compensated for curvature, but easement or transition curves have been introduced wherever possible, with the result that the trains ride very easily. In the tunnels and on the viaducts, of course, it has been impracticable to put in these transition curves. Black stakes marked "E. O." and "E. 3" (or as the case may be), are set at the ends of curves to mark where the superelevation begins and reaches its full amount. The right of way boundary is marked very conspicuously and clearly by white posts at frequent intervals.

The elevation above sea level at Cincinnati is about 500 ft.; at Waynesburg, 139 miles, the road has attained a summit elevation of 1,248 ft., and then descends to Somerset, 158 miles, with an elevation of only 872 ft. It begins to rise again at the Cumberland River, reaching an elevation of 1,257 ft. at Upland, 177 miles; while the highest summit on the road is at mile-post No. 209 (from Cincinnati), with an elevation of 1,519 ft. The line then descends steadily, until at the Chattanooga terminal it is only 677 ft. above sea level.

One particular feature of the road, which is noticeable by the casual passenger as well as by the engineer, is the freedom from dirt in the cars. Dust is eliminated by the use of stone and slag ballast for almost the entire length of the line, while excellent combustion (due to the use of firebrick arches, air inlets and the "one-shovel" system of firing), all aid in reducing the amount of smoke and cinders emitted to a minimum, which would hardly seem possible when the heavy trains and the heavy grades are considered. Experiments have also been conducted with the Kincaid automatic stoker for locomotives.

ROADBED AND TRACK.

The standard width of roadbed is 18 ft. on banks, 12 ft. in rock cuts and 16 ft. in earth cuts (exclusive of ditches). The road is single track, ballasted for almost its entire length with about 12 ins. of stone or slag, so that there is very little dust. The ties are of oak, obtained mainly along the line of the road. The track was originally laid with 53-lb. steel and 60-lb. iron rails, but is now laid entirely with 75-lb. rails of the No. 528 Cambria or No. 75 C. Carnegie section.

both being the same. Some of the old Edgar-Thomson 53-lb. rails made in 1879 gave remarkable service under severe traffic, and showed but slight indications of wear after some 12 years service. This is attributed to the thorough rolling at a low temperature which was given to rails made at that time, while the small section aided in securing a thorough compressing and compacting of the metal throughout the whole

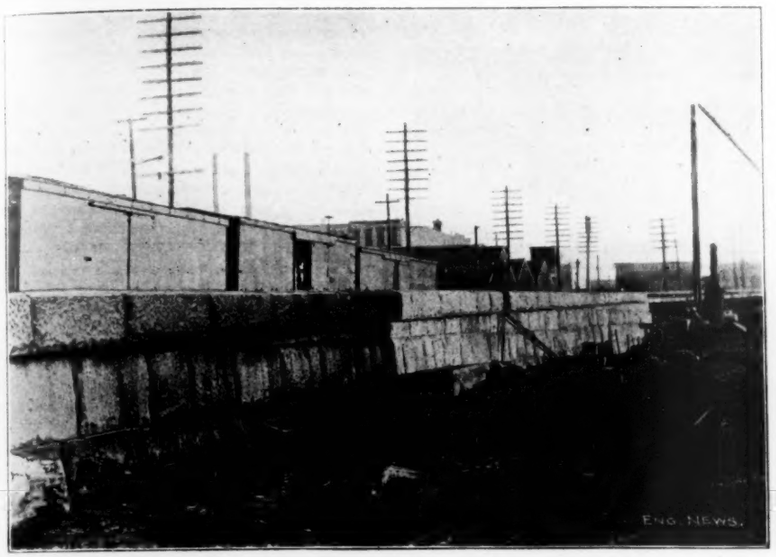


FIG. 2. NEW MASONRY APPROACH TO THE OHIO RIVER BRIDGE, CINCINNATI, O.; CINCINNATI SOUTHERN RY.

body of the rail. The chemical analysis of these rails shows little reason for such service, and is as follows: Carbon, 0.327%; phosphorus, 0.0922%; manganese, 1.780%; silicon, 0.035%; sulphur, 0.067%. These rails were removed on account of the increasing weight of engines and rolling stock. The Weber joint, with six bolts, is now largely used. The sidings are laid in part with 60-lb. rails.

Split switches and spring-rail frogs are used throughout the main track. At main line terminals, high switch targets are used, with semaphore signals 1,200 ft. distant from the switches of passing sidings.

The road was originally built to the Southern gage of 5 ft., but this was changed to standard gage in 1886, in which year nearly all the broad gage lines of the Southern states were similarly changed.

The track is kept in good line and surface, with regular curves and uniform superelevation. The ballast is neatly sloped, and a sod line is maintained along the toe of the ballast, or at a little distance from it, with a cinder path intervening. Careful attention is given to the maintenance work, and after the annual inspection each November, prizes are awarded to the best sections, these sections being indicated by signs put up on the section tool houses. For many years Southern railways had a bad name for construction and maintenance, but the Cincinnati Southern Ry. has been an example of first-class work from its very beginning. In 1899, Mr. P. H. Dudley made an inspection and autographic record of the track with his dynagraph car, and reported very highly as to its condition.

BRIDGES.

Iron bridges and viaducts were extensively used in the original construction of the road, the viaducts being generally composed of steel towers 30 ft. wide, with 30 and 60-ft. Fink deck truss spans between them. Some of the timber trestles have been replaced with shorter metal structures having bank approaches. Many of the culverts and waterways had masonry walls supporting timber stringers of 12½ to 20-ft. span, but these stringers are now being replaced with steel I-beams or plate girders on the old abutments. At the present time there are 104 iron and steel bridges and viaducts, aggregating 29,474 ft. in length, and 23 timber trestles and other structures (mostly on side tracks) aggregating 2,820 ft. in length.

The iron structures were substantial enough for the engine and train loading of their day, but are too light for modern equipment. They form the limiting condition of the operating service, not being strong enough to safely and economically carry such engines as would otherwise be used for the traffic. They were designed for ten-wheel engines having 24,000 lbs. on each of the three driving axles, followed by a train load of 1,820 lbs. per ft. The present heaviest engines are consolidation engines, having 26,450 lbs. on each of the four driving axles, but these can only be used on certain parts of the line, where bridges have been renewed or strengthened.

The largest bridge is that over the Ohio River at Cincinnati, which was completed in 1877. On the north side, the approach comprises six truss spans; 121 ft., 113 ft., 118 ft., 190 ft., 190 ft. and 191¼ ft. long. The bridge proper has two 300-ft. spans at the north end, a 519-ft. channel span, and a 370-ft. draw span. From the latter a 110-ft.

Fig. 3. Standard Style of Tunnel Portal; Cincinnati Southern Ry.

short span extends to the high ground of the Kentucky shore. The total length of the bridge and approaches is 3,822 ft.; and of the river spans, 1,489 ft. The river spans and piers were built by the Keystone Bridge Co., under the designs of Mr. J. H. Linville, M. Am. Soc. C. E. The Cincinnati approach was built by the Baltimore Bridge Co. The river piers were built in open cofferdams and are founded on rock. The bridge has a single track, and the rail level is 106 ft. above low water, at which stage the channel is 14 ft. deep, and the maximum rise of the river has been 71 ft. The total cost of the structure was $802,172. The bridge was described in Engineering News of Nov. 24, 1877, and Jan. 15, 1881.

Owing to the low elevation of the ground on the Ohio side, a timber trestle 1,235 ft. long, with a grade of 1½%, led up to the approach spans of the bridge proper. About 586 ft. of this trestle was replaced in 1900-01 by a solid embankment between masonry retaining walls, while 749 ft. will be replaced with a steel viaduct. Fig. 2 is a view looking south towards the bridge, showing the commencement of the masonry, which is of a very massive character. The old trestle appears at the right, with the engine and derrick used in erecting the retaining wall. In the completed work the tops of the ties are about level with the top of the wall, and there are no outside guard timbers. Inside iron guard rails are used, however, as on all the bridges. The masonry is of Indiana limestone. This work is being executed by Paterson, Collier & Co., 1364 Monadnock Block, Chicago.

The bridge ranking next in importance is the famous "High Bridge," over the Kentucky River, which was built in 1876-77 to the designs of and erected under the direction of the late Mr. C. Shaler Smith, M. Am. Soc. C. E., then Chief Engineer for the Baltimore Bridge Co., and the total cost of the structure was $404,370. The bridge is 1,138 ft. long, and consists of three deck truss spans of 375 ft., the trusses being 37 ft. 6 ins. deep, with parallel chords. The rail level is 275 ft. above low water, and the trusses are supported by two steel towers 214 ft. 9 ins. high, on masonry piers 71 ft. 3 ins. high. The bridge was erected from each end, as a cantilever, temporary wooden towers built midway under the shore spans being the only falseworks used. During erection the projecting spans were anchored back of the old masonry towers erected for a suspension bridge planned for the same site in 1854 by Mr. John Roebling. The suspension bridge was never built, but the old towers now serve as portals for the truss bridge, the tracks running through the archways of the towers. The structure was erected as a continuous girder, but in order to allow for expansion without disturbing the piers, it was divided into three parts after completion. This was done by putting in hinge joints 75 ft. on the shore side of each pier, so that the structure consists of a central girder of 525 ft. and two end girders of 300 ft. in length.

The Cumberland River bridge, near Burnside, Ky., has three main spans of 199 ft., and its total length, with iron viaduct, is 1,335 ft. The rails are 157 ft. above low water. This bridge cost $178,700. The Tennessee River bridge, at Hixson, Tenn., is 1,804 ft. long and has eight spans; four 207 ft., two of 208 ft., one of 257 ft., and a draw span of 280 ft. The rails are 63 ft. above low water. This bridge cost $315,530, and was built by the Louisville Bridge & Iron Co.

One of the long high steel viaducts, at McKees Branch, has a combination of old and modern construction. It is 809 ft. long and 129 ft. high. The original construction comprised steel towers 30 ft. long at the top, connected by Fink truss spans of 30 and 60 ft. On April 21, 1899, a derailed freight train went over the trestle and wrecked 330 ft. of the south end. For rebuilding, a modern style of construction, much heavier than the old viaduct, was adopted, and it was proposed to rebuild the entire structure. Owing to the financial conditions of the road, however, and to the fact that the accident was in no way caused by a failure of the structure, it was decided to rebuild only the wrecked portion of the viaduct.

TUNNELS.

There were originally 27 tunnels on the road, varying from 189 ft. to 3,984 ft. in length, the latter being the tunnel through Kings Mountain, which was at the head of a 1% grade 5 miles long. The tunnels in good solid rock were left unlined, but timber lining was put in wherever the rock was not self-supporting. The timbering consisted of posts 12 × 12 ins., with sills and wall plates, carrying arch roof ribs of approximately semi-circular form, or made of two inclined timbers and a horizontal cap or crown timber. The roof lagging was mainly of sticks 6 × 6 ins., while 6-in. and 3-in. side lagging was placed outside the posts.

In the original construction of the road the total length of tunnels was 26,338 ft. Of this amount,

18,444 ft. of timber-lined tunnels or tunnels in disintegrating rock have been completely arched, and 855 ft. additional have had side walls of timber replaced by brick masonry. The approaches of tunnel No. 27 have given considerable trouble from the unstable character of the rock, which has an inclined bed, and once slipped so as to force the timber lining inward. In 1898, serious falls of rock occurred at the south approach, and traffic was temporarily blocked, trains being sent over a roundabout route. A diversion has recently been

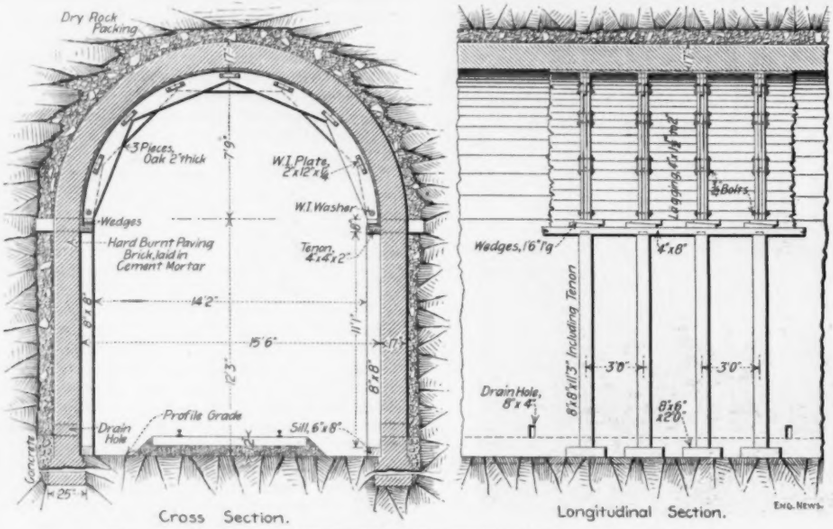


FIG. 4. STANDARD CENTERING AND BRICK LINING FOR TUNNELS.

completed on a new location by which this tunnel will be avoided, as described further on. In regard to the statement as to the character of the rock encountered in the tunnels, it may be noted that most of the rock along the line is shattered and disintegrated, there being very little stone suitable for building purposes. For this reason brick is largely used for recently-built culverts, piers, etc., and for lining the tunnels.

In some cases, stone side walls and a brick arch are used, and most of the brick-lined tunnels have stone arch rings at the portals, as shown in Fig. 3. In one tunnel, where the roof was in good solid rock, and the sides in loose shale rock, brick side walls have been built to the springing line, leaving the roof untouched. The policy of lining the tunnels was adopted before the use of concrete came into such general favor, as it at present possesses, and it has not been considered advisable to change the original methods of work.

Fig. 4 shows the brick lining of one of the tunnels, with the timber centering used in its construction. The lining is 17 ins. thick, increased to 25 ins. at the foundations, which are carried 6 to 18 ins. below the grade line. It is of hard-burned paving brick, laid in cement mortar. Concrete backing is used to a height of 12 ins. above the grade line, at which point there are drain holes 8 × 4 ins., spaced varying distances apart, according to the quantity of water encountered. Above the concrete, dry stone packing is filled in between the brick lining and the rock. The clear dimensions inside the lining are 15 ft. 6 ins. in width and 20 ft. in height.

The centering consists of posts 14 ft. 2 ins. apart, set on sills, and supporting continuous wall plates. The arch ribs are made of three thicknesses of 2-in. plank, put together with iron straps and ¾-in. bolts. The feet of the ribs rest upon wedges on the wall plates. The ribs are covered with the lagging. The centering is supported at the springing lines by short 8 × 8-in. timbers, fitted between the wall plates and the rock. These are removed at the same time as the centering, and the spaces left are filled with bricks laid in cement. The centering is built in sections about 10 to 30 ft. long, and is usually struck four to eight days after the completion of the brick work.

OPENING A TUNNEL.

Tunnel No. 6, near Alpine, was only 189 ft. in length, and had a very shallow cover. In fact, some of the original cuts were deeper than would have been required at this point, and the wisdom of adopting a tunnel instead of an open cut is considered open to question. At any rate, it was resolved to open up the tunnel and make a cut, and this work was completed in April, 1901. The earth was first excavated by wheel scrapers and the rock roof then drilled and blasted. During the removal of each length of the roof, a train of flat cars was run into the tunnel, so that the material could be easily and promptly removed, and the track quickly cleared to allow trains to pass. The contractors for this work were H. H. Squair & Co., of Cincinnati, O. Fig. 5 is a view of the tunnel, showing the timber lining, and the timber cribbing to fill the voids above the crown, and also showing the disintegrated character of the rock. Fig. 6 is a view from above, showing the removal of the earth over the rock roof.

NEW LINE AROUND TUNNEL NO. 27.

As already noted, the last tunnel on the line, No. 27, near Emory Gap, has given trouble, the disintegrated shale rock having slipped at one time and crowded in the timber lining (although the lining was exceptionally heavy). It has sometimes been difficult to maintain the line safe for traffic through the approaches, and in fact serious falls of rock have occurred, particularly in the northern approach. In 1898, a slide of decomposed shale over the portal at the south end of the tunnel slipped and overturned a few bents of timber lining. On removing the slide it left a length of 25 ft. as open cut. In 1899, the improvement of this part of the line was carefully investigated, and it was at first proposed to enlarge the tunnel and put in a strong masonry lining. Surveys for a diversion to avoid the tunnel altogether were also made, and a very satisfactory location was found. The estimate showed that it would be cheaper to build this new line than to improve the tunnel and put in a brick lining.

A map of the present and new line is given in Fig. 7, but does not show the topography of the country. The new line is 1.65 miles long, making it 0.3-mile longer than the old line. It swerves off to the southeast, skirting the ridge pierced by the tunnel, and follows along the course of the Emory River until the ridge is passed, when the line returns again to the original location. Slight improvements are made in the profile and alinement, and it will be noted that transition curves are introduced. Some very heavy work was involved, and owing to the broken and distorted character of the country only approximate estimates could be made of the character and quantities of the material. The heaviest cut is nearly a mile long, and 52 ft. deep in its deepest part, while 75% of its excavation is in rock, much of this being loose rock. A profile of the new line is shown in Fig. 8. The actual embankment amounted to 151,000 cu. yds.

In March, 1900, the contract was let to M. J. Condon & Co., of Knoxville, Tenn., and the new line was completed in November, 1901. Mr. Gustaf Bottiger was the Resident Engineer in charge. About 2½ miles of narrow gage construction track have been in use, laid with 35-lb. rails, and on this were run dump cars for making the embankments and for dumping surplus material to waste. The earth was excavated by plows and wheel scrapers, as well as by pick and shovel work, and when the rock was reached Ingersoll-Sergeant compressed-air drills were used, with steam derricks for loading the dump cars. Fig. 9 shows the plow and scraper work in excavating the upper portion of the big cut at the south end of the line, and Fig. 10 shows the rock excavation at the north end of the cut. Fig. 11 is a view of the large embankment at the north end of the line, which was built in two stages or lifts, as is clearly shown. The view shows the filling being done by dump cars. Fig. 12 is another view of the south end of the same embankment, showing an 8-ft. arch brick culvert, and in this view the filling is being done by dump cars. This culvert, shown in Figs. 8 and 12, runs under the bank at an angle of 65° with the tract. It has concrete foundation walls 4 ft. 9 ins. wide and 4 ft. deep, with brick side walls 3 ft. 6 ins. thick and 4 ft. high, the backs of the walls being carried up to form haunches extending nearly to the top of the arch. The arch is semicircular, 4 ft. radius, built with four rings of brick laid on edge. The invert has 12 ins. of concrete and a single course of brick paving. The culvert is 210 ft. long from face to face, and contains 510 cu. yds. of brick masonry, 200 cu. yds. of concrete, and 70 cu. yds. of brick paving.

Fig. 5. Tunnel Before Alteration.

Fig. 6. Stripping Roof of Tunnel.

OPENING UP A TUNNEL ON THE CINCINNATI SOUTHERN RY.

BLOCK SIGNALS AND INTERLOCKING.

The road is operated very largely on the block system, and is protected, for the greater part of its length, by automatic block signals of different styles. Across the Ohio River bridge to Ludlow, and from Ludlow to Crescent Springs, the traffic is worked by the train staff system, there being one staff station on the Ohio side and three on

the Kentucky side. This system is also established from Erlanger to Dickson, from Norwood to Somerset, and from Oakdale to Harriman Junction, covering a total of 18 miles of road. Manually operated semaphore signals are erected at the staff stations. The divided staff is used, one-half being taken from and delivered to the operator by the fireman, and the other half by the conductor or rear brakeman. On the First District, Cincinnati Division (79 miles), the automatic block signals are of the semaphore type, installed by the Hall Signal Co. The home and distant signals are painted yellow with a black stripe; the same colors being also used for the semaphore train-order signals. On the Second District, Lexington to Norwood (74 miles), the block signals are of the banjo type, having a red banner or disk moving up and down in front of an opening in the case. These are of the Union and Hall patterns, practically the same in their operation and appearance. The Chattanooga Division, extending from Somerset to Chattanooga, is equipped between Somerset and Lancing (80 miles), with the clock-work disk signals of the Union Signal Co. The disks turn on a vertical axis, so that, to show clear, they stand parallel with the track, presenting an edge view and disclosing a white background. When at danger the full face of the disk is shown. From Lancing to Oakdale (12 miles), the Union "banjo" form is used. Between Harriman Junction and Chattanooga (84 miles), the Union semaphore is used, similar in form and appearance to the Hall semaphores in use on the Cincinnati Division.

The maintenance of these signals is in charge of a Signal Engineer on each division: Mr. W. A. D Short, on the Cincinnati Division, and Mr. F. J. Hemphill, on the Chattanooga Division. To signal inspectors, or maintainers, are assigned from 12 to 18 signals, in sections about 18 miles in length, where signals are continuous. These maintainers visit every signal daily, making a careful inspection The whole system of block, train-order and interlocking signals is under the direction of Mr. G. L. Lang, Superintendent of Telegraph.

The system of block-working on this road was described in full in our issue of March 10, 1898, and has developed from the introduction of automatic signals in 1891 to protect the tunnels, forming an independent block section for each tunnel. All passenger trains carry a track velocipede in the baggage car, for use by the head flagman when necessary to flag a block. These cars are fitted with brackets for holding a red flag during daylight and a red and white lantern at night, and also carry torpedoes and fusees.

Highway crossings are generally equipped with gong signals. There are six railway grade crossings on the line, all of which are protected by interlocking plants. In addition to the railway grade crossing towers, there are ten interlocking switch towers for handling switches in yards and at busy points. At passing sidings, there are distant signals which are operated from the switchstands.

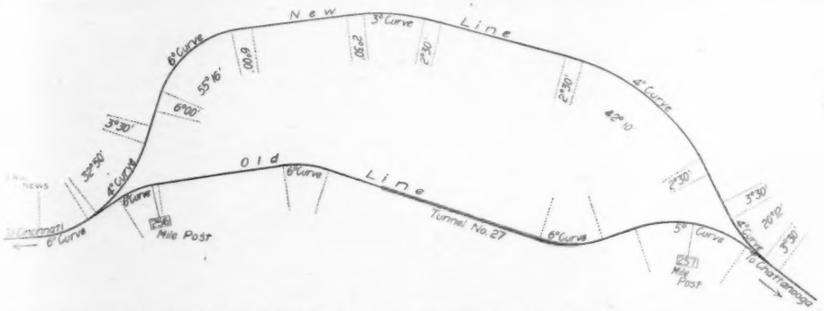


FIG. 7. PLAN OF DIVERSION TO AVOID TUNNEL AT EMORY GAP, TENN.; CINCINNATI SOUTHERN RY.

LOCOMOTIVES AND CARS.

The locomotive equipment is modern, and includes some handsome passenger engines. The weight of the engines is comparatively light, in view of the heavy engines now very generally employed in freight service on other roads, but the weight is limited by the capacity of many of the existing bridges. Mr. J. P. McCuen is Superintendent of Motive Power, with offices at Ludlow, Ky.

The standard simple passenger and freight engines are shown in Fig. 13, and their leading dimensions are as follows:

	Passenger.	Freight.
Type	10-wheel.	Consolidat'n.
Driving wheels	5 ft. 8 ins.	4 ft. 4 ins.
Truck wheels	2 " 9 "	2 " 6 "
Tender wheels	2 " 9 "	2 " 9 "
Wheelbase, driving	14 " 6 "	14 " 10 "
" truck	8 " 0 "	.....
" engine	28 " 9 "	22 ft. 8 ins.
" eng. and tender.	52 " 3½"	49 " 8¼"
Weight on drivers	84,000 lbs.	106,000 lbs.
Weight on truck	36,000 lbs.	14,000 lbs.
" of engine	120,000 "	120,000 "
" of tender, loaded	96,000 "	94,000 "
Cylinders	19 x 24 ins.	20 x 24 ins.
Boiler, diameter	4 ft. 10 ins.	5 ft.
Boiler pressure	180 lbs.	180 lbs.
Firebox, inside	78 5/16 x 34⅜"	107 11/16 x 38⅝"
Tubes, No.	244	238
" diameter	2 ins.	2 ins.
" length	13 ft. 2 ins.	13 ft. 5 ins.
Heating surface, tubes	1,670.6 sq. ft.	1,662.2 sq. ft.
" " firebox	140.8 "	149.0 "
" " total	1,811.4 "	1,811.2 "
Grate area	18.7 "	25.0 "
Coal	8½ tons.	8 tons.
Water	4,500 galls.	4,000 galls.

Two of the ten-wheel passenger engines are Baldwin four-cylinder compounds, with cylinders 13 x 24 and 22 x 24 ins. The ten-wheel passenger engines have blind tires on the middle (main) drivers, but some of the consolidation freight engines have flanged tires on all the driving wheels. These latter are found to work very satisfactorily even on the numerous and sharp curves, the axles being given a slight excess of lateral play in the boxes. All the passenger engines are equipped with Boyer speed-recorders (driven from a grooved pulley outside one of the truck wheels), and Pyle electric headlights. The motor and dynamo are mounted on the boiler just in front of the cab, and current is supplied to the marker lamps and to lamps at the steam gage, water gage and in the hood of the cab. Each marker lamp is connected in series to one of the cab lamps, so that in case of its going out the engineman would be notified by the cab lamp also going out. The bulb in the marker lamp casing would then be unscrewed and a hand lamp put in. Electric lamps are not placed under the running board for use in oiling-up, as is done on some other roads. In the first place, these lamps soon get so greasy and dirty as to give very little light, and are frequently broken, while in the second place a portable lamp or torch is almost a necessity in oiling-up and inspecting.

Particular attention is paid to smokeless firing, which is a benefit to the traveling public and a source of fuel economy to the railway. The fire-boxes of the passenger engines are specially designed to burn the fuel with as little smoke as possible. As shown in Fig. 14, the firebox has a brick arch, the lower end of which is just below the bottom of the boiler barrel, while the upper end is above the level of the top of the fire door. This arch is supported on four inclined water

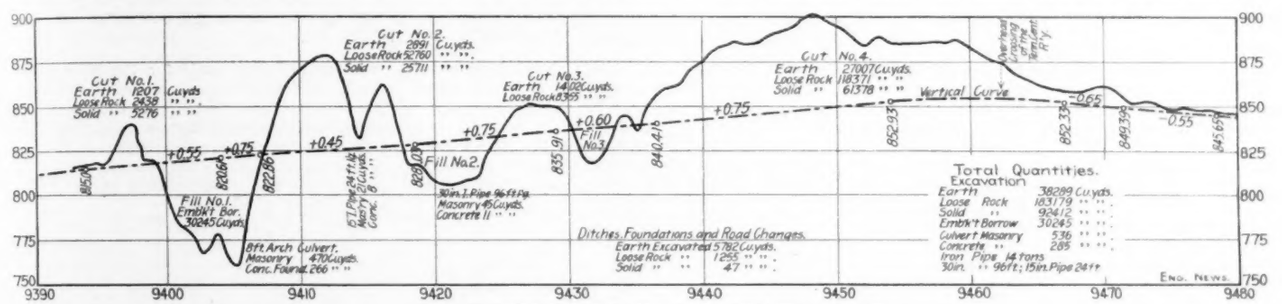


FIG. 8. PROFILE OF NEW LINE AROUND TUNNEL.

Fig. 10. Rock Excavation at North End of Big Cut.

Fig. 9. Earth Excavation at South End of Big Cut.

HEAVY EXCAVATION ON NEW LINE; CINCINNATI SOUTHERN RY.

tubes which enter the front water leg and the space above the crown sheet. Through the bricks run four 2¼-in. tubes, whose lower ends are fitted into 2½-in. tubes, which extend across the water leg and are open to the atmosphere. Their upper ends are open into the firebox, being flattened to form elongated apertures. The air passing through these tubes is heated to a high degree,

Ludlow shops. At present there are under construction at these shops 150 box cars, 34 ft. long, of 60,000 lbs. capacity, weighing 28,000 lbs.; and 50 stock cars, 38 ft. long, 60,000 lbs. capacity, and 35,000 lbs. weight. All these will have M. C. B. couplers, and the Buckeye steel trucks. These trucks have I-beam frames and transoms, with large gusset-plate connections, and the springs are

Tires which are to be set or removed are heated by gasoline jets on a ring which encircles the tire. The wheel fits of all wheels are bored in a special machine to fit the wheel-seat of the axles, the axles never being turned to fit the wheel.

The plant includes a wood-working shop, machine shop, blacksmith shop, tank shop, (in the roundhouse), and brass foundry. In the latter the

FIG. 11. BANK BUILT IN TWO STAGES.

FIG. 12. BANK AND 8-FT. BRICK CULVERT.

EARTH EMBANKMENTS ON NEW LINE; CINCINNATI SOUTHERN RY.

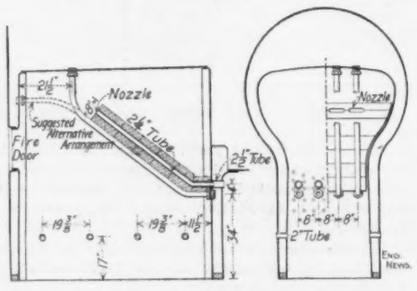
and helps to promote complete combustion by supplying oxygen to the unconsumed gases as they pass over the upper edge of the arch. On each side of the firebox, about 12 ins. above the grate, are four 2-in. tubes for the admission of air, and these are so arranged as to deflect the air directly to the fire. The use of these devices in connection with strict rules for enginemen and firemen as to the handling of the engines and the "one-shovel" system of firing, enable the desired results of so-called smokeless firing to be obtained.

A special feature of the equipment of this road is that all the passenger engines have vestibule frames on the tenders, which fit against the vestibules of the baggage or mail cars, and so reduce to a minimum the liability of the telescoping of these cars by the tender in case of an accident. The value of this arrangement as a safety device has received practical demonstration. It may be remembered that this tender vestibule arrangement (Pullman patent) was first introduced in 1893 on a Rogers engine attached to a train exhibited by the Pullman Car Co. at the Columbian Exhibition at Chicago, but it has not been adopted to any great extent. The tenders originally carried 4,000 gallons, but are being enlarged to carry 4,500 gallons of water and 8½ tons of coal. This enables the passenger engines to haul the "limited" trains over the mountain division of 93 miles without a stop for water. Runs of 158 miles are made with one load of coal. Steel-tired truck wheels are used on all engines and on all passenger tenders.

between the axles. Oak for car work is obtained along the line of the road, but the pine comes mainly from Mississippi.

SHOPS.

The main shops are at Ludlow, Ky., three miles from Cincinnati, where engine repairs are made and cars are built, as already noted, but no en-



Longitudinal Section. Cross Section.

Fig. 14. Firebox with Brick Arch and Air Tubes; Cincinnati Southern Ry.

gines are built. About 100 freight engines and 50 passenger engines have to be taken care of at these shops. One of the principal features of interest is the extent to which compressed air is used in connection with the various shop tools, etc. It is used for air hoists over the machine tools, etc., for air riveters (by pressure, not hammering), for painting cars, and for operating the traversing table in the yard. It is also applied to a yard-testing plant for testing the brakes after trains have been made up. A large Ingersoll-Sergeant compressor is used, and the air-pipe line carries a pressure of 100 lbs.

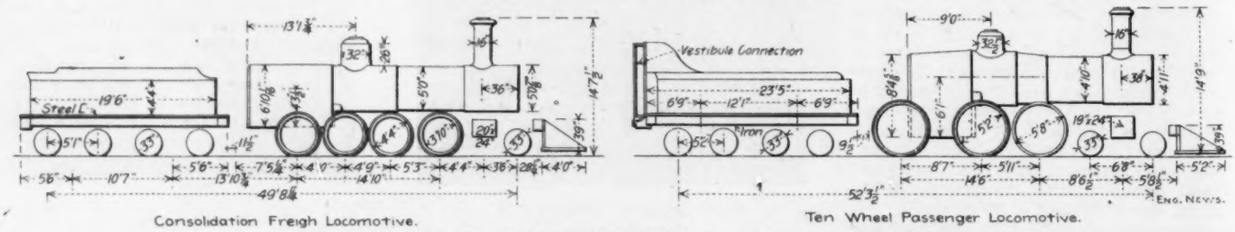
castings are now made for the railway by contract. A roundhouse, storehouse, oil-house, coaling station, water tanks, and office (with drafting room) complete the principal equipment.

Besides these main shops there are also shops at Somerset, Ky., and Chattanooga, Tenn. At the latter place are wood-working shops, a car shop, and a small repair shop.

OPERATION.

For operating purposes the line is divided into two divisions: Cincinnati to Somerset and Somerset to Chattanooga. Mr. H. M. Waite, of Lexington, Ky., is Superintendent of the Cincinnati Division; and Mr. M. W. Maguire, of Somerset, Ky., is Superintendent of the Chattanooga Division.

The through passenger trains are made up usually of seven or eight cars, including three or four sleeping cars, and a parlor observation and dining car on the day trains. Occasionally the load is as high as ten cars, which is heavy work for the ten-wheel engines on the long steep grades. With the ordinary trains a speed of 60 miles an hour is frequently maintained, and without discomfort to the passengers. Freight trains average 35 to 40 cars on mountain portions of the road, and are usually run as double-headers, three freight cars being placed between the head and second engines in order to prevent undue concentration of load on the bridges. Although the engines are necessarily worked pretty heavily, the absence of smoke and cinders is very noticeable. This is due in part to the use of firebrick arches, with an inlet pipe



Consolidation Freigh Locomotive. Ten Wheel Passenger Locomotive.

FIG. 13. STANDARD LOCOMOTIVES OF THE CINCINNATI SOUTHERN RY.

J. P. McCuen, Superintendent of Motive Power.

Freight cars are built at the main shops at Ludlow, Ky., but the work can only be done during fine weather, as it has all to be done on outdoor tracks. Some handsome dining cars have been built by the Barney & Smith Car Co., and 50-ft. mail cars have been lengthened to 60 ft. at the

and deflecting tubes, and in part to the enforcement of the use of the one-shovel system of firing. The firebox arrangements are described above, and the rules for firing, in order to burn bituminous coal without smoke, were described in our issue of Aug. 21, 1899.

An important feature of the equipment for promoting the safety of freight trains is the provision of air-brake testing plants in the yards at Ludlow, Somerset, Oakdale and Chattanooga. Here the brakes on all trains are tested under a pressure of 100 lbs., after the trains are made up, thus insuring the efficiency of the brake equipment when the train starts out.

Another feature of the operating department is the use of the stereopticon in instructing and examining the men. After block signals began to be generally used, the management were somewhat alarmed to find that many of the men did not heed the signals because they did not understand them, and were not inclined to ask for information for fear of displaying their ignorance, and perhaps being discharged. The matter was taken up very carefully by Mr. W. J. Murphy, the General Manager, and a system of instruction was instituted by means of lectures and classes, followed by periodical examinations which the men are required to pass. It was found that diagrams were not entirely satisfactory in instructing the men as to the meaning of signals, etc., and the idea was conceived of making use of the stereopticon lantern and photographic slides for this purpose. During the lecture a view will be shown taken on the track, and showing a signal in a certain position. The signal and its surroundings are at once familiar to the men, and they are questioned as to the meaning of the signals in the different positions shown in the various views. The lectures are given at different points along the line, and form part of the system of examination. This "stereopticon" system of instruction was originated by Mr. W. J. Murphy, who is now General Manager of the C., N. O. & T. P. Ry. Co. (lessee of the Cincinnati Southern Ry.), and a description of it has been published in book form.

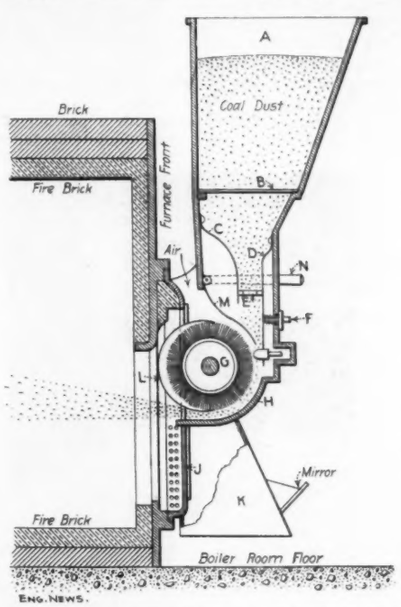
A ROTARY BRUSH SYSTEM OF FEEDING PULVERIZED FUEL TO FURNACES.

Of the numerous systems which have been devised for burning coal in a pulverized form, a majority employ air jets or forced draft to blow the dust fuel into the furnace. In the Hesselmeyer & Schwartzkopff system, which is now being introduced into this country, the fuel is thrown in by means of a cylindrical brush revolving at high speed. Different forms of mechanism for feeding the fuel-dust mechanically were tried by these inventors before the brush was adopted. One of these consisted of a small horizontal paddle wheel across the furnace front, the spaces between the paddles forming hoppers which were filled from the main hopper, the dust being thrown intermittently into the furnace by the centrifugal force of the wheel. The brush, however, has the advantage of giving a continuous feed, and of distributing the dust in a finely divided form.

As a result of tests with an experimental apparatus at Maywood, Ill., the Illinois Central R. R. has had eight of these devices applied to two of its six 150-HP. tubular boilers in the boiler house at 14th St., Chicago, and four at the 27th St. power house, while the Otis Elevator Co., of Chicago, has also applied them to a water-tube boiler of 150 HP. In fitting up these boilers, the grates were removed, and a brick combustion chamber built, in order to maintain the required high temperature. This chamber is about 6 ft. long, extending 2 ft. into the boiler room, and just beyond the end of the chamber is a brick bridge wall which diverts the flame and gases upwards instead of allowing them to pass directly to the flue. The system may, with slight modifications, be applied to any kind of boiler.

A sectional drawing of the feeding device or automatic stoker is shown in the accompanying cut. The hopper, A, is attached to a casting on the furnace front, and has a screen at B to catch any foreign bodies in the finely-powdered coal. Pivoted to opposite sides of the hopper are two thin brass plates, C and D, connected by a link E, so that they move together. A spring, F, holds the larger plate, D, normally close against the brush, G. This brush is about 16 ins. long and 10 ins. diameter, driven at about 900 revolutions per minute, by a small pulley on its shaft, with a belt from an overhead shaft, which may be driven by a small steam engine or an electric motor. This brush revolves in a casing H, open at the upper part of the back for the feed, and at the lower part of the front for the discharge into the furnace. The lower part of the casing, at J, has numerous air holes and a damper by which the draft is regulated. The shield, K, prevents the radiation of heat into the boiler room, and is provided with a metallic mirror by which the influx of coal dust may be watched. On the middle of the brush shaft is an eccentric, L, which at each revolution strikes the lower end of the plate, D, forcing it back, and so causing a continuous rapid motion or vibration of the two plates, which prevents any choking or clogging of the feed. The curved plate, M, may be raised or lowered by the hand lever, N, so as to give a wider or narrower feed opening from the hopper to the brush.

The fire is started by burning wood or waste in the furnace and then turning on the fuel dust. Any kind of coal may be used, and very cheap coal burned in this way is claimed to give nearly as high efficiency per unit of combustible contained as expensive coal burned in the ordinary way. There is no opening of the furnace door for stoking, which admits cold air to chill the fires and boilers, and with a proper regulation of the air supply there is no smoke. Looking into the furnace, there is seen a long bright flame, somewhat similar to that seen in an oil-fired furnace. There is very little labor required, one man easily feeding the hoppers of four or six stokers, and attending to the draft, while the accumulation of fine ash dust is only cleaned out every few days. Tests made in Germany have shown that only 2.69% of the calorific value of the coal was lost in this dust. The system is applicable not only to boilers, but also to cement kilns, welding and other furnaces. It is in use for these various purposes in Europe.



Section of Automatic Stoker for Pulverized Fuel. Schwartzkopff Coal-Dust Firing Co., Chicago.

The system was first introduced in Europe in 1894 by Mr. Richard Schwartzkopff, and later Mr. A. C. Hesselmeyer became associated with him. The latter has for several years devoted himself to the improvement of fuel combustion, and is now in this country as Technical Manager for the Schwartzkopff Coal Dust Firing Co., 903 Security Bldg., Chicago, Ill. Mr. Hesselmeyer has also developed special grinding machinery for pulverizing the coal, as some difficulty has been experienced in getting the required fineness with rapidity and economy in machines now in the market. The new mills now in use have a capacity for producing three to four tons of coal dust per hour. One of these mills is to be installed in the boiler house at the Illinois Central R. R.

The Schwartzkopff system was tested in 1896 by a German government commission appointed to test smoke-consuming appliances. As the boiler was used also for testing safety appliances it was not built in, and there was consequently considerable loss of heat by radiation and convection, but it was estimated by the commission that under normal conditions the gases would leave the boiler at a temperature of 392° F., and that the loss by radiation would be about 7½%. During a three-day test, using three kinds of coal, the following results were obtained, the combustion being in each case practically smokeless:

		Natural draft.		Forced draft	
Test:	Fuel.	Efficiency from fuel.	Evaporation, lbs. of water per lb. of coal.†	Efficiency from fuel.	Evaporation, lbs. of water per lb. of coal.†
First day. ..	A	82.35%	11.23	78.04%	10.64
Second day .	B	83.33%	12.20	79.58%	11.28
Third day ..	C	80.33%	6.97	75.49%	6.55

† Water at 212°.

A—Upper Silesian bituminous coal; B—Westphalian bituminous coal; C—Bohemian lignite or brown coal.

In 1900, a report on the Schwartzkopff system was made by Mr. A. Bement, M. Am. Soc. M. E., 218 La Salle St., Chicago, and from this report we take the following extract:

> My opinion of the Schwartzkopff system and apparatus is decidedly favorable. It embodies the only rational method of coal-dust firing, because the feed of fuel and supply of air are each independent of the other and allow of individual adjustment, which is necessary for successful working. The economic performance that may be secured by its adoption will insure an important saving over general prevailing practice, and in addition thereto, an economy in labor. The apparatus also insures a smokeless combustion.

SLIDE RULE COMPUTATIONS FOR LAYING OUT CURVES.

By Henry T. Stiff.*

The facility and accuracy with which the laying out of curves and calculations incident thereto can be effected by means of the slide rule, has been recently impressed upon the writer. In the calculation of curve data, as in all calculations with the slide rule, an approximate value of the required result should be mentally determined, since the rules for finding the decimal point only add to the complexity of the problem. The use of the slide rule obviates the necessity of the ordinary field-book with its tables of sines, unless the degree of curvature is so large that the curve data cannot be determined with sufficient accuracy with the rule. Since the sines of small angles are approximately proportional to the angles themselves, the upper scales A and B of a Mannheim slide rule may be converted into a table of natural sines.

The largest probable error in reading the upper scales of the rule should not exceed 2.5 in 1,000, which is about equal to the average cumulative error caused by assuming that the natural sine of 4° is proportional to the sine of 1′. The above error would make a difference of 0.02-ft. in the location of a 100-ft. chord point in an 8° curve. It will be found most convenient for the purpose of curve work to fix on the left-hand side of scale B by dot or line the value of the reciprocal of the sine of 1′, which value is 3,437.+ This point will be called the gage point.

Given a radius of 800 ft. to find the degree of curve (D): Under 50, the half chord, on scale A, set 800 on scale B, then over the gage point on scale B find 215′ on scale A, which is one-half the degree of curve, or D = 7° 10′.

Given a 9° curve to find the radius: Under half the degree of curve expressed in minutes and decimals set the gage point; then under 50 find the required radius 637 ± on scale B. It will rarely be necessary to find the exact radius in the field, and an approximate one will be accurate enough for work within the province of the slide rule.

The deflection angle necessary to establish any subchord point is found as follows: Given a radius of 1,300 ft. to find the deflection angle for a subchord of 70 ft. Under one-half the subchord set 1,300, then over the gage point find 92⅛′, or 1° 32′ 30″. The reading thus obtained is less than 15″ in error, and as the ordinary field instrument seldom reads to less than half minutes, the deflection angle is within the limit of accuracy of good field practice. Unless for approximate locations, for which the slide rule is admirably adapted, it will not be advisable to lay off deflection angles for 100-ft. chords when the radius of curvature

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is less than about 800 ft., or in general when the radius is less than eight times the subchord.

In railroad work the curve is measured by 100-ft. chords, whereas in street line and sewer work the actual arc is measured. The difference between a 100-ft. chord and the actual arc is nearly proportional to the square of the degree of curve. The value of the excess of arc per station for a 1° curve will be fixed on the left-hand side of scale A at .00127. Setting the index to this gage point, the excess of arc for a 2° curve is found on scale A over 2 on scale C to be 0.005-ft.; over a 7.33° curve on scale C find 0.068-ft. and over a 12° curve find 0.183-ft.

The above setting may be used for curves up to 25° without making an error of .01-ft. per station. Having found the excess of arc per station for the given degree of curve, the difference between the arc and chord for any subchord point is found by multiplying the above excess by the 3d power of the given subchord expressed in decimal parts of the whole chord.

Let it be required to stake out the intermediate 50-ft. stations of a 5° railroad curve. Since the chord distance will be more than 50 ft., the excess will be found as follows: The excess of arc for a 5° curve per station is 0.032-ft., and for 50 ft. the excess of arc is 0.016-ft.; the difference between the 50-ft. chord and its arc is found by multiplying .032 by .50³, which gives .004. Therefore, the length of chord will be 50.016 — .004 = 50.012.

Suppose a line of a certain sewer is laid out on a curve of 1,300-ft. radius, and it is required to establish a point on the center line which will measure 90 ft. on the arc. First find the degree of curve and also the excess of arc per 100-ft. chord. Multiply this excess, found to be .024-ft., by .90³ and obtain .018-ft. The required length of chord, therefore, is 89.982 ft.

Having established several subchord points on the curve, they may be conveniently checked by the tangent offset method. The tangent offset for a given degree of curve is found on scale A over the index figure when the slide is set by the formula for finding the degree of curve. Then over any subchord distance on scale C find the required tangent offset on scale A.

The writer has used the slide rule exclusively for several years in running out curves, and can confidently recommend it for its accuracy and as a means of saving time, the party in the meantime being kept continually at work.

A NEW METHOD OF TESTING FIRE-RESISTING QUALITIES OF FIREPROOFED WOOD

By Ira H. Woolson,* E. M., M. Am. Soc. M. E.

The construction of fireproof buildings is literally a "burning question" at the present time. If any additional incentive were needed to spur the building fraternity to renewed efforts in this direction it would be furnished by the list of fearful fires which have occurred during the past few weeks. Fortunately the gravity of this problem was realized here in New York several years ago, and the Building Department has conducted a long and very valuable series of practical tests upon all sorts of so-called fireproof materials, which have resulted in a standard of fireproof building construction in this city superior to any in the country. However, the results thus far obtained are only relative, and the problem as a whole is by no means solved. There are a number of uncertain facfors which must be eliminated by experience.

One of the most perplexing of these is the question of the use of "fireproof" woods. There are to date five fireproofing processes which have been favorably passed upon by the New York Building Department (during the preceding administration), the processes controlled, respectively, by (1) the American Wood Fireproofing Co., (2) the Electric Fireproofing Co., (3) the New York Fireproof Wood Co., (4) the Fireproofine Co., and (5) the Riscinate Wood Fireproofing Co. Of these five processes some were accepted upon the basis of results obtained from rigid tests, while others were accepted upon very insufficient evidence. The processes differ widely in character, and, due to this, and also to the variations in the wood itself (in its natural condition wood varies much in character within the same species, and often in the same tree), the products of the different processes are of widely divergent values, some being very good, others quite poor. To determine just what could in justice be expected of "fireproof" wood has been the troublesome question.

The New York building code requires that the woodwork in all buildings over 12 stories, or 150 ft., in height shall be fireproofed, and it can be safely said that no clause in the building code has contributed more generously to destroy the general peace of mind of the Building Department, during the past year, than this one. In endeavoring to establish a standard, the department has instituted a number of investigations, both public and private, to determine the relative merits of the different processes.

It has been the writer's pleasure as a disinterested party to conduct a number of these investigations, both for the department and for the wood fireproofing companies, and stimulated by the results obtained, as well as by the general paucity of reliable information on the subject, the writer has instituted a series of comparative tests, upon his own account, in an effort to formulate some standard method of testing the wood for fire-resisting qualities, which might furnish a fairly accurate measure of value. This work has included over 400 separate tests, all carried out within the past eight months.

The present paper deals with a portion of the results obtained from these experiments; it is at best only a "report of progress," the data presented, and the methods by which they were obtained, being by no means complete or conclusive. The only excuse for presenting it in this incomplete condition is the very active interest being taken in the subject just now by engineers, architects, builders, insurance companies and the general public, together with the demand for some positive method by which the effectiveness of a "fireproofing" treatment may be measured. By thus bringing to the attention of those interested that which has already been done, it is hoped that suggestion and criticism may be elicited, which may be of service in the continuance of these investigations, which the writer has already under way. For the information of those unfamiliar with the subject matter it should be stated, that the term "fireproof wood" is, in a sense, a misnomer; for such woods will burn in all cases, if exposed for a sufficient length of time to a high degree of heat. Strictly speaking, the processes of treatment do not make the woods fireproof, but they simply render them fire retardants, and it is only in this way that they become valuable for certain purposes. The question then to decide is, (1) what degree of "fireproofness" or fire resistance in the products of the "wood fireproofing" processes shall be required, and (2) after establishing that point, what kind of test shall be employed to determine if the specification is maintained.

Up to the present time, so far as the writer has been able to ascertain, only three methods of testing "fireproof" woods for their fire-resisting qualities have been regularly adopted: (1) the building test, (2) the shavings test, and (3) the splinter test.

Fig. 1. Combustion Pan for "Navy Standard" Test.

The first-named consists of building a small house, in regular form, of the wood to be tested, usually duplicated by a house of untreated wood, and then applying a vigorous fire both inside and out, and noting results. This method possesses spectacular elements which are very convincing, and while it may be useful as a general test to demonstrate the degree of immunity from fire that a wooden building may be made to possess, the heavy expenditure of time and money required for such a test precludes the possibility of employing it for regular series work.

Right here it should be remarked that serial tests on fireproofed woods are even more necessary for maintaining a standard quality than are serial tests of iron, steel or cement. The results of a fireproof test of a year or two ago should no more be used in purchasing lumber for use in a building to-day than the purchase of armor plate for a new battleship should be based upon tests made for that of the battleship "Oregon." For protection to the purchaser, some method of test must be adopted by which a constant check can be kept upon the quality of the lumber as it is delivered.

The shavings and splinter tests adopted by the U. S. Navy aim to accomplish this object, but while the tests are useful in determining, in a general way, the merits of two or more samples of fireproofed woods, it is believed that a consideration of facts presented below will convince any one of their unreliability as a standard method of test, and the absolute impossibility of obtaining uniformly accurate comparative results by their use. The shavings test is conducted as follows: a pan one foot in diameter and about six ins. deep is mounted on legs, as shown in Fig. 1. The bottom of the pan is formed by a heavy wire screen of about ½-in. mesh. This wire bottom is covered with a layer of shavings 2 ins. deep and a Bunsen burner is applied underneath until the shavings begin to blaze (usually about 20 to 30 seconds); then the burner is removed and the lengths of time during which the shavings support (1) flame and (2) glow, are recorded, as well as the area of shavings burned.

The idea at the bottom of this test is that shavings from properly treated wood will not support flame any appreciable length of time, and that the flame will gradually die out without material enlargement of the burned area, when the burner is removed.

No definite length of time, or sizes of burned area permissible are mentioned in the specifications. After making over 100 of these tests the writer is convinced that no such limits could be set which would be fair at all times. These details must be left to the individual judgment of the operator. This introduces a personal element, which is unsatisfactory, and which should be avoided in any standard test. After the test is finished the remaining shavings are thrown away, for there are no means for making a permanent exhibit of the results of the test, except by photographs, which would be very difficult to take with uniformity and quite unsatisfactory. The wood must be accepted or rejected on the judgment of the operator, based upon notes taken, while observing the test.

Besides these obvious disadvantages, there are two other very strong objections to the shavings test: first, the extreme difficulty of always maintaining the same conditions of flame and heat under the shavings, and, second, the impossibility of securing a uniform quality of shavings for tests. The Navy specification calls for the use of a Bunsen burner with a flame giving about 500° Centigrade = 932° Fahrenheit. Now, Bunsen burners vary considerably as to the size and kind of flame which they produce, so that, although every precaution was taken and the same standard temperatures were determined in each of two flames at some definite point, the results of tests upon the same kind of shavings might, due to the general variation in the character of the flames, show widely divergent figures. Much depends also upon how and where the tests are conducted, whether under a smoke hood with a mild or strong draft, or in an open room where drafts

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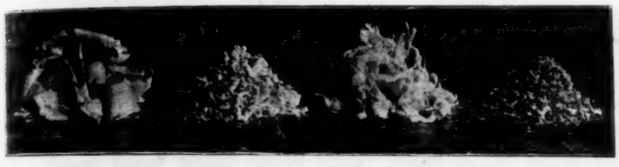
of air could strike the flame and cause it to dance and sway. The flame of a Bunsen burner is quite sensitive, and experiments made with a pyrometer couple held in the flame, have shown that a variation of over 100° was easily obtained by the effect of a person walking briskly about the table on which the experiment was being conducted.

The most serious objection, however, to the shavings test, and the one which, in the writer's opinion, is fatal to its use as a standard method of comparison, is the impossibility of making the shavings of uniform size and quality. Fig. 2 is a photograph of samples of shavings made from yellow pine boards, treated by four different "fireproofing" processes. The shavings were all made by the same carpenter, with his plane set to the same depth of cut, and were made as nearly alike as he could make them. Of these four sets of



Process "A." Process "C." Process "D." Process "E."

FIG. 2. SHAVINGS OF TREATED YELLOW PINE, DIFFERENT FIREPROOFING PROCESSES.

White Pine Red Oak

Process "B." Process "D." Process "C."

FIG. 3. SHAVINGS OF TREATED PINE AND OAK.

shavings, one is like coarse sawdust and could all easily be sifted through a ¼-in. mesh sieve. The other extreme among the set of four is so coarse that it would scarcely go through a 2-in. mesh. Between the two are all gradations. Fig. 3 shows at the right a similar set of two specimens of red oak shavings from pieces of wood treated by different processes; the same variation in quality of shavings will be noted as in Fig. 1, the shavings in one pile being fine and string-like, the shavings in the other pile broad and firm. At the left in Fig. 3 are shown two specimens of white pine shavings from boards treated both by the same process; again is the wide variation in quality of shavings noticeable, thus proving that while the character of the treatment undoubtedly has some effect upon the quality of the shavings, it is not responsible for all of the trouble. The samples shown in Figs. 2 and 3 are only a few from a large collection of shavings of all the common treated woods in the writer's possession, but the whole collection shows the same great diversity in the character of the shavings.

It would seem that without further evidence, the inappropriateness of this test as a standard of comparison, may be considered demonstrated. This rejection of the shavings test as a standard is based entirely on the ground that the test could never be expected to give reliable or concordant results; it may be noted, however, as an objection of a different character, that no wood in the form of shavings would be exposed to fire in the burning of the ordinary building, so that it would be extremely difficult to properly interpret any results obtained by the shavings test.

The splinter test is made by putting small splinters of the wood to be tested upon a plate of iron heated to dull redness, the requirement for "fireproofness" being that they should char but not flame. While the test has value in showing the ability of a specimen to withstand flaming under such conditions, still the great difficulty of getting splinters of a standard shape and size, due to causes already mentioned, limits its use to determining this one property.

It was in an effort to avoid these numerous difficulties that the writer devised a new method of test, the "timber test," and employed it in making a large number of tests of different treated and untreated woods. It is believed that the "timber test" has accomplished the object sought. Experience has shown that certain modifications as regards size, temperature or time of exposure may be advisable, but in the main essentials it is thought the test will bear the most rigid investigations.

Specimens 1 in. square and 1 ft. long were selected from the same relative place in each board to be tested. These "timbers" were tested in pairs (either duplicates, or comparison pieces from two different processes), by being laid across the top of a 6-in. gas crucible furnace, shown in section and plan in Fig. 5, in which a constant temperature of 1,700° F. was maintained. At the end of two minutes the specimens were removed, held in the air, and duration of (1) flame and (2) glow noted for each. The temperature was measured by placing the couple of a Le Chatelier pyrometer across the mouth of the furnace, between the two specimens and about ½-in. from each. This arrangement gave the temperature of the furnace at the point of application of the wood. A constant check upon the temperature variations throughout each test was obtained by watching the pyrometer needle, but records were only made at the beginning and end of each test. The initial temperature was always the same—1,700° F.—but the final temperature, due to the added heat of the burning wood, was increased varying amounts, according to the variety of the wood under test and character of the "fireproofing" treatment. The proportions of gas and air were regulated to furnish a vigorous flame action to a height of 6 to 8 ins. above the furnace, thus imitating an ordinary fire. The particular temperature of 1,700° F. was chosen because it is the one given by the New York Building Code as approximately that of a burning building.

After the tests the specimens were sawed in two transversely at the middle of the length of each, and tracings were made of the outline of the section of unburned wood remaining. The areas of these tracings were then very carefully measured by a planimeter, and the percentage ratios to the original cross-section of the stick (1 sq. in.) were calculated. Fig. 4 is a photograph showing the general appearance of specimens after test, and after cutting in two. The exhibit embraces both treated and untreated wood, and attention is directed to the fact that, in all cases the treated wood remains intact on the upper side, or side not directly exposed to the fire. (In Fig. 4, all samples shown have their bottom faces turned up, i. e., they rest upon the face which was at the top while the specimen was being tested.) This leaves the top surface of the tested samples of treated wood with a straight line in the cross-section, whereas the samples of untreated wood were burned on all sides; a piece of soft wood, like the white pine shown at J or L, has only a small portion of solid unburned material remaining at the center.

Fig. 6 shows a group of characteristic tracings of cross-sections of tested "timbers," illustrating the method of making a permanent record of the effects of tests. The tracings shown in Fig. 6 are average results obtained from various species of wood, treated by different "fireproofing" processes, and also in their natural untreated condition. They illustrate good, bad, and indifferent "fireproofing" treatments, and are fair examples of the practical operation of the test under the conditions stated. It will be noted that the processes are not given by name, but are marked by reference letters, A, B, C, D and E. This was done because the samples under some of the processes were taken from regular commercial stock, while those under the other processes were especially prepared for test; a direct comparison between them would therefore be unfair, although it may be remarked that in most instances little difference was noticed between the behavior of the two kinds of samples.

Referring to Fig. 6, the square outline indicates the original cross-section, always 1 in. on a side; the black portion shows the part burned to charcoal, while the remaining solid wood is left white; the percentage figure marked on each diagram gives the ratio of the unburned area to the original area of cross-section. The tendency of the untreated specimens to burn on all sides is evident in each variety of wood. In the case of yellow pine it will be noted that the two untreated samples gave better tests than some of the treated specimens. In the absence of other confirmatory tests, it is impossible to determine with certainty the cause for this, but it is supposed to be due partly to the pitchy character of the wood, and partly to an excessive treatment which injured the wood fiber, thus aiding disintegration.

In general the untreated wood showed a cross-section area loss approximately 15 to 25% more than the treated samples. However, the value of a "fireproofed" wood cannot be rated by this feature of the test alone. Account must be taken of the tendency to ignite and support combustion. This is indicated by the duration of flame, and the duration of glow, after the specimen is removed from the fire.

The accompanying table gives a summary of tests on different kinds of wood. It is by no means complete or conclusive, but it illustrates the data obtained in regard to the different fire-resisting properties of the wood, and the general relation between treated and untreated material:

In every instance the contrast in time of flame and time of glow, between the treated and the untreated wood, is very marked. In the case of yellow pine the average duration of flame, for the 10 specimens given, was about 14 seconds for all processes, while the average for 8 specimens of untreated wood was 2 minutes, or a ratio of about 1 to 10. In the case of white wood, the average flame for treated wood was 4 seconds, and the average for untreated wood was 2 mins. 48 seconds or a ratio of 1 to 42. All the woods show approximately the same conditions, both in flame and glow.

This measure of the property of supporting combustion is equally as important as the determination of the percentage of unburned area, for in the first stages of a fire minutes of prevention are

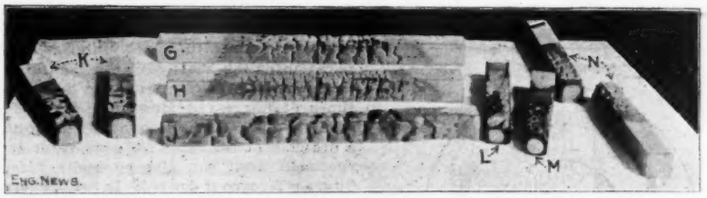


FIG. 4. SAMPLES OF TREATED AND UNTREATED WOODS, TESTED FOR FIRE-RESISTING QUALITIES BY "TIMBER" TEST.

G = Ash (Treated); H = White Pine (Treated); J = White Pine (Untreated; K = White Ash (Treated); L = White Pine (Untreated); M = Red Oak (Untreated); N = Red Oak (Treated).

Summary of Results of "Timber Test" of Various Woods Treated by Different "Fireproofing" Processes.

Variety of wood.	Process used.	Duration of flame. Maximum.	Minimum.	Average.	Duration of glow. Maximum.	Minimum.	Average.	Unburned, %. Maximum.	Minimum.	Average.	No. of specimens.
Yellow pine	A	0' 59"	0' 2"	0' 20"	0' 59"	0' 6"	0' 22"	56	52	53	4
	B	0' 4"	0' 4"	0' 4"	0' 9"	0' 4"	0' 7"	68	64	66	2
	C	0' 39"	0' 11"	0' 25"	0' 20"	0' 16"	0' 18"	46	42	44	2
	E	0' 11"	0' 6"	0' 9"	0' 12"	0' 11"	0' 12"	37	37	37	2
	Untreated	3' 25"	0' 55"	2' 00"	3' 25"	1' 37"	2' 10"	58	50	54	8
White pine	A	0' 7"	0' 6"	0' 6"	0' 15"	0' 15"	0' 15"	46	44	45	2
	B	0' 4"	0' 1"	0' 2"	0' 16"	0' 13"	0' 14"	64	61	62	2
	C	0' 9"	0' 3"	0' 7"	0' 14"	0' 8"	0' 12"	54	51	53	4
	D	0' 6"	0' 5"	0' 6"	0' 10"	0' 10"	0' 10"	51	51	51	2
	E	0' 5"	0' 3"	0' 4"	0' 14"	0' 7"	0' 11"	55	50	52	4
	Untreated	1' 13"	0' 22"	0' 40"	1' 13"	0' 38"	0' 59"	38	33	34	6
Red Oak	A	0' 9"	0' 5"	0' 6"	0' 12"	0' 7"	0' 9"	62	54	58	3
	C	0' 10"	0' 4"	0' 7"	0' 10"	0' 8"	0' 9"	60	60	60	2
	E	0' 7"	0' 5"	0' 6"	0' 16"	0' 14"	0' 15"	53	46	49	2
	Untreated	2' 26"	0' 25"	1' 31"	4' 5"	0' 14"	2' 26"	46	40	43	8
White oak	Untreated	2' 34"	0' 6"	1' 27"	3' 18"	1' 35"	2' 32"	61	50	56	6
White ash	A	0' 7"	0' 6"	0' 6"	0' 10"	0' 6"	0' 8"	59	56	57	3
	B	0' 7"	0' 0"	0' 4"	0' 20"	0' 7"	0' 12"	71	62	67	4
	E	0' 14"	0' 14"	0' 14"	0' 26"	0' 14"	0' 20"	53	44	48	2
	Untreated	1' 13"	0' 35"	0' 51"	7' 14"	4' 13"	5' 35"	46	43	44	4
Whitewood, or yellow poplar	A	0' 5"	0' 3"	0' 4"	0' 9"	0' 7"	0' 8"	54	47	51	3
	B	0' 5"	0' 3"	0' 4"	0' 8"	0' 7"	0' 7"	51	49	50	2
	E	0' 6"	0' 2"	0' 4"	0' 12"	0' 7"	0' 9"	47	43	45	2
	Untreated	2' 52"	2' 18"	2' 48"	4' 23"	2' 38"	3' 31"	37	32	35	4

worth hours of cure. The question of the time and temperature necessary for actual ignition is also important, and one upon which little information is at present obtainable. The writer has some ideas as to a proper method of measuring this property which he hopes to exploit in the near future along with the other work. At present he is greatly handicapped by the lack of necessary assistance and funds to prosecute such investigations. Experimental work of this character requires much time if it is to be done thoroughly, and if it is worth doing at all it is worth doing well; it involves, further, a considerable expense in the preparation of specimens, drafting, and other work.

A small variation in unburned cross-section area must be allowed on account of structural differences in the wood. Experience thus far indicates that 5% is ample for the best processes, and in many instances the variation between a number of duplicate specimens would not exceed 2 or 3%.

Besides the varieties of wood given in this table, numerous tests have also been made upon maple, cherry, mahogany, black ash, spruce, etc., but those given are sufficient for the purposes of this paper. As oak is so largely used for interior finish it is a matter of regret that more data can not be given in relation to that species. A large number of tests on oak and spruce now almost completed are, unfortunately, not far enough along to be available for this paper.

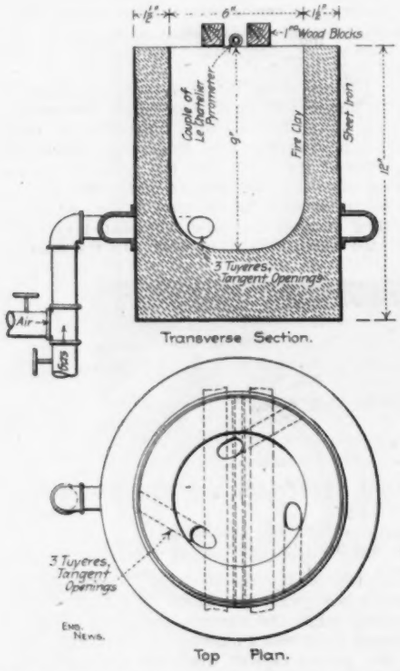


Fig. 5. Six-Inch Gas Crucible Used for "Timber Test."

White oak and long leaf yellow pine are essentially "slow burning" woods, and from the results of preliminary tests made upon untreated and treated samples, it is quite possible that further investigation will show that so far as preserving the structural strength of the material in a fire is concerned, it may not be at all necessary to treat these woods to the center of the piece, particularly where thicknesses of over 2 ins. are employed. A surface treatment would probably always be desirable, for reasons already mentioned. The lighter and more porous woods should be treated throughout, and tests should always be made to determine the degree of interior treatment, for there seems to be considerable variation in different processes, in this particular.

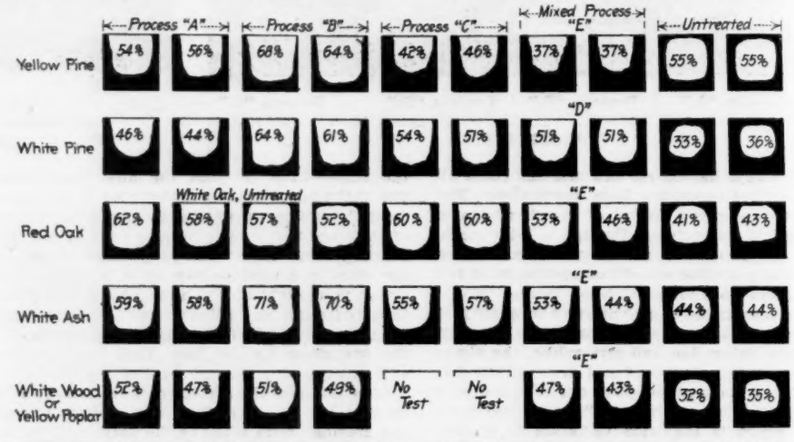

Process "A"
Process "B"
Process "C"
Mixed Process "E"
Untreated
Yellow Pine
54% 56% 68% 64% 42% 46% 37% 37% 55% 55%
"D"
White Pine
46% 44% 64% 61% 54% 51% 51% 51% 33% 36%
White Oak, Untreated
"E"
Red Oak
62% 58% 57% 52% 60% 60% 53% 46% 41% 43%
"E"
White Ash
59% 58% 71% 70% 55% 57% 53% 44% 44% 44%
"E"
White Wood or Yellow Poplar
52% 47% 51% 49% No Test No Test 47% 43% 32% 35%

FIG. 6. RESULTS OF "TIMBER" TEST FOR FIRE-RESISTING QUALITIES OF VARIOUS WOODS TREATED BY DIFFERENT FIREPROOFING PROCESSES.

Briefly stated, the advantages of the method of test presented in this article are: (1) A test piece of uniform size, large enough for practical comparisons, and small enough to enable numerous tests to be made with slight waste of material, thus ensuring a fair average report: (2) a constant temperature and uniform time of application of the heat; (3) an estimate of the tendency to support combustion as indicated by the times of flame and glow; (4) the ability to accurately measure the amount of burn, and to make a drawing of the same for permanent record—the specimen itself can also be easily preserved for future reference if desired. In brief, every element of the test is constant except the character of the wood and the treatment it has received, and necessarily these must always remain variable. The first of these can be estimated to a close approximation by a sufficient number of tests upon untreated samples, and the latter must be determined by the test itself.

In conclusion, attention is called to the fact that there are other important qualities of "fireproof" wood which should receive thorough investigation parallel with tests of its "fireproofness," for instance, the effect of the chemicals employed in the treatment upon nails, screws and metal fittings, also the tendency of these chemicals to deliquesce, and cause the wood to gather moisture during damp weather (this is found to be quite objectionable with some treatments); the effect of the treatment upon paints should also be studied. The question of permanency is another important matter; that is, whether the chemicals used are stable or whether they will evaporate or decompose under atmospheric conditions, so as to leave the wood in time without the protection originally given.

It is generally conceded that fireproofing processes have a tendency to make wood brittle, and lessen its strength, but for ordinary uses this is not sufficient to be objectionable; in this day of steel construction, wood is seldom called upon to sustain much weight. The writer has made a number of tests for strength, and has data from many similar tests, all of which indicate that the wood is not seriously injured by treatment. It must be stated, however, that in most cases, there is no evidence that the wood tested for strength had been treated to a proper degree of "fireproofness." It is a fact that overtreatment or undue haste in treatment does injure the wood fiber materially. In some instances which have come under the writer's observation, the injury has been so great as to practically ruin the wood. The test for strength should, therefore, be made in connection with the fire test in order to keep the proper balance between full treatment and overtreatment.

Another point should be taken into consideration, namely, whether the wood when attacked by fire and forced to burn, would give off obnoxious fumes. With wood treated by one process of those which the writer has tested the gases and smoke given off during combustion were so suffocating that it is doubtful whether a fireman could exist in a room where this material was burning. Fortunately, this fault does not appear to be general with wood "fireproofing" processes. This same defect of obnoxious fumes, the writer has found existing in some fireproof partition materials when subjected to intense heat. It should receive proper consideration when determining the value of such mixtures, for although they may not burn, still when other things about them are burning, if they give off suffocating gases sufficient to prevent free action of the firemen, their value is thereby depreciated unless it may be proved that the gases so released by heat are themselves fire retardants. The U.S. navy has made extensive and valuable investigations in connection with some of these questions, particularly as regards strength tests parallel with fire tests, but much still remains to be done.

As stated in the early part of the present paper, the all-important question confronting the public to-day in reference to this subject is: What is Fireproof Wood; in other words, what degree of fire-resistance shall be accepted as sufficient and equable between manufacturer and purchaser? This question is not easy of solution, and will require much careful investigation before it is satisfactorily solved.

As the final answer must necessarily be more or less arbitrary, it should not be decided by the opinion of any one or two men. It should be formulated from the consensus of opinion of some committee composed of manufacturers of fireproof wood, building commissioners, insurance under-

writers and other experts whose judgment would be of value in this connection. A decision from such work based upon full and careful investigative work would remove the uncertainty which now exists, and place the matter on a scientific basis.

In view of the awful losses of life and property by fire which are constantly occurring, the question is of vital importance to all civilized humanity, and no effort should be spared to learn all that may be learned in regard to anything which will tend to lessen our frightful fire calamities.

A NEW STADIA-ROD.

The stadia-rod here shown was devised to overcome the inconvenience of transporting 15-ft. rods in passenger coaches, in making small hydrographic surveys. Strips of paper, each one foot long and marked as shown in the diagram—but without the finer graduations, were first tried. These strips were tacked on any strip of board available, and they made a fairly serviceable temporary rod.

But if the survey lasted for several days this arrangement proved unsatisfactory, and the design here illustrated was developed. This consists of 15 aluminum plates, each 1-32-in. thick, 3½ ins. wide and 1-64-in. less than one foot long. Each plate is graduated to tenths and hundredths, as shown; and all figures are exactly .5 of a foot high; the bottom of the figures being placed on the foot-mark. All even numbered plates have the graduations on the right-hand side; and the odd plates are graduated on the left. This arrangement assists in counting the number of feet when the rod is so far away that it is difficult to read the figures. The finer graduations are only useful for short sights, or when the rod is employed in leveling.

The aluminum in a strong light is far superior to any painted rod; and in a poor light it is neither better nor worse than white paint. The marking is in black; done in a baking enamel submitted to a temperature of 275° F. for three hours. The hundredths can be marked in red, if desired. These plates are fastened to the board by screws, and adjusted to position by a steel tape. The great advantage of this rod is that it can be carried in the coat pocket, as it weighs only 1½ lbs. It is as well suited to accurate work as any other rod, and it is especially well adapted to rough and rapid work. The cost of the plates, exclusive of work put upon them, was $3.65. This stadia-rod was devised by Mr. A. S. Cooper, U. S. Asst. Engr., Savannah, Ga., and he has found it preferable to other forms of rod in his hydrographic surveys.

A NEW METHOD OF DETERMINING THE VELOCITY OF UNDERGROUND WATER.

By Chas. S. Slichter.*

Engineers are familiar with the chlorine or chemical method of determining the rate of motion of underground water, in which the time of passage of a charge of common salt from one test well to another is determined by chemical analysis. The earliest instance of a test of this character with which I am familiar was a successful attempt to trace the origin of an underground vein of water encountered in building a tunnel in Switzerland. Thiem used the same idea in numerous investigations in Germany about 1887, since which time the method has become the standard in such work.

A more rapid and less laborious scheme for surveying underground currents of ground waters than the chlorine method becomes almost imperative when extensive surveys are undertaken. Since July, 1901, the writer has given much attention to the development of an entirely new method intended to be especially applicable to the survey of the underflow streams of the plains. With the approval of Mr. F. H. Newell, Chief Hydrographer of the U. S. Geological Survey, I made preliminary field tests along the valley of the Arkansas River in Western Kansas during the month of August, and I have continued the work in the laboratory and field since that time. The outcome seems to leave little to be desired either in the certainty of the results or in the rapidity with which the work can be carried on. The method is an electrical one. A double row of 1¼-in. drive wells is sunk across the channel of the river whose underflow is to be tested. The upstream wells are then charged with a strong electrolyte, which dissolves and passes downstream with the moving water.

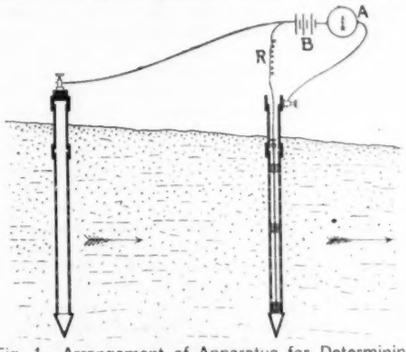


Fig. 1. Arrangement of Apparatus for Determining the Velocity of Ground Water by Slichter's Electrical Method.

(A = ammeter; B = battery; R = resistance. The arrow shows direction of supposed motion of the ground water.)

The passage of the electrolyte toward the lower well is shown by the gradual movement of the needle of an electrical instrument, and the final arrival at the well is shown by a sudden and strong deflection of the needle. It is exceedingly interesting to watch the gradual movement of the water in this indirect way. In an hour or two a very good indication of the rate can be obtained by noting the slope of the current curve already obtained. If several of a row of wells are being used simultaneously, the main stem of the underground current will show itself by the rapidly rising electrical currents corresponding to certain of the wells. Thus not only are the tedious chemical analyses of the chlorine method done away with, but the actual movement of the water is traced from the very beginning of the experiment, a result which is impossible in the older methods.

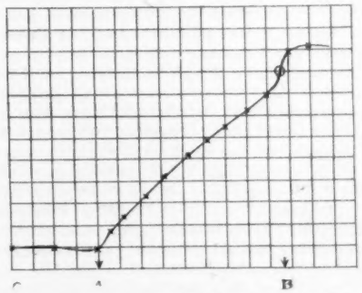


Fig. 2. Chart of Electrical Current Obtained by Slichter's Method of Determining Velocity of Ground Water.

(Horizontal divisions represent time. Electrolyte placed in upper well at time corresponding to A, and reached lower well at time corresponding to B, the time of arrival being shown by the "notch" in the curve. A B represents time of passage of ground water from well to well.)

Numerous electrolytes have been tried in the laboratory and the field. It is obvious that the electrolyte must possess the following properties:

(1) It must be readily soluble in water.

(2) It must be chemically inactive to the dissolved matter in natural waters or to the material of the pervious medium.

(3) It must possess a low coefficient of diffusion.

(4) It must possess a high conductivity.

(5) It must be low in cost.

Of the numerous salts tried up to the present time, ammonium chloride has given much the best results. With this salt a current of sufficient intensity to throw the needle of a recording ammeter can be obtained by the use of a few dry cells.

The electric circuit to the wells can be made in various ways. A brass rod, insulated from the well tube, and lowered into the downstream well by means of a rubber-covered wire, may serve as one electrode, the casing of the same well constituting the other electrode. In this case the indication of the movement of the groundwater will not be noted until the electrolyte has reached the lower well, where its presence will be shown by a sharp rise in the current curve. Instead of this, the two wells themselves may be used as the electrodes, in which case the gradual passage of the electrolyte downstream can be observed from the beginning, but the final indication of its arrival at the lower well is less pronounced. The best method is a combination of these two. The wire from the casing of the lower well is run to one pole of the battery with the ammeter in circuit. The other pole of the battery is connected both to the internal electrode of the lower well and to the casing of the upper well. In this case the gradual movement of the groundwater from one well to the other is shown on the ammeter chart, and an abrupt indication of the arrival of the electrolyte at the lower well is also recorded.

The drive wells may be made of perforated sections from 4 to 6 ft. long, so that a well will offer free passage to the water throughout its entire depth. The brass-rod electrode may be made in several insulated links, with separate external wires, so that varying velocities at different depths may be readily determined.

The writer has made preliminary tests of the rate of movement of the underflow of the Arkansas River in Western Kansas, and has found rates varying from 3 to 15 ft. per day. The results have been sufficiently encouraging to warrant a systematic survey of the underflow of that portion of the stream.

*Professor of Applied Mathematics, University of Wisconsin, Madison, Wis.

NOTES FROM THE ENGINEERING SCHOOLS.

PURDUE UNIVERSITY.—A second historic locomotive has been deposited with the university by the Baltimore & Ohio R. R. Co., through Messrs. J. N. Barr, F. L. Underwood and F. D. Casanave. This engine is of the old "camel-back" type, originated about 40 years ago by Mr. Ross Winans. "No. 173" was built in 1868, and was in regular service until withdrawn for presentation to the university. With this year Purdue University opens a new department of instruction in telephonic engineering, to train men in this particular branch of electrical engineering.

STEVENS INSTITUTE.—We gave some account last week of the elaborate ceremonies which were recently held on the occasion of the formal opening of the new Carnegie Laboratory of Engineering at this institution.

On the day following the dedication Mr. Carnegie forwarded to President Morton a check for $100,000 for the endowment of the Laboratory.

THE PUMPING ENGINE CONTRACT LITIGATION at Cincinnati, O., has resulted in a jury award of $238,712 in favor of the city and against the Lane & Bodley Co., of Cincinnati. The contract was awarded to the company named several years ago. After long delays in its execution, the city cancelled the contract, called for new bids, and finally awarded a new contract to the Camden Iron Works, at an advance of $302,600. The city thereupon sued the Lane & Bodley Co. and its bondsmen, the American Bonding Co., for this excess price, with the result stated above. The company will contest the award.

A GASOLINE MOTOR ASH WAGON is to be tried by the Department of Street Cleaning of the City of New York, which is now under the direction of John McGaw Woodbury, M. D., Commissioner of Street Cleaning. The wagon will have a capacity of about 6 cu. yds. and will be tested in a district where the hauls are long. The wagon is not yet built.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

The isthmian canal question is "up to" the deliberative branch of Congress now, which means, we need hardly say, that speedy action upon it is not to be looked for. At present, the Senate Committee on Interoceanic Canals, which has the matter in charge, is holding hearings, preliminary, it is supposed, to the presentation of a report. Senator Morgan, the Chairman of this committee, is well known to be for the Nicaragua route, first, last, and all the time. Indeed, he is about the only one left of the old-time advocates of the Nicaragua route who were so vociferous in its favor years ago, when the old Maritime Canal Company was trying to have its chestnuts pulled out of the fire. The preferences of the other members of the committee in the matter of route are variously stated, but it appears likely that a considerable division of opinion exists. It is even reported that the grotesque Mandinga route, with its four-mile tunnel, has won the hearts of some distinguished Senators, which, if true, speaks volumes for their lack of sound judgment.

So much is being published in the newspapers of late concerning this Mandinga route, that a few words concerning it here may be appropriate It is talked of as if it were a newly-discovered solution of the isthmian canal problem. In reality it is nearly a half-century old. Its present promoters know nothing themselves concerning it that is not already a matter of public record.

Its advocates' chief claim for it is that it is a sea-level canal, while Nicaragua and Panama require locks; but as the Isthmian Canal Commission points out in its report, if a sea-level canal were deemed a necessity, it could be better made at Panama than at Mandinga, and no tunnel would be required at Panama. Further, the concessions held by the Panama Co. are broad enough to cover the Mandinga region as well, so the Panama company's rights would have to be bought up, the same as for the Panama route.

The paramount objection to the Mandinga route, however, is the tunnel. Such a work would be an experiment wholly unprecedented. No ship canal tunnel has ever been built or operated. In fact, no tunnel of anything like so great a cross-section has ever been driven. The Mandinga promoters speak glibly of a "tunnel through solid granite;" but neither they nor any one else knows anything about the character of the rock to be penetrated. It may be granite (though the geological chances would seem to be against it), and it may be a swelling shale of such a character that driving such a large tunnel through it would be a practical impossibility.

Again, the promoters talk of making the tunnel safe against falls of rock from the roof by lining it. Engineers who know the strains to which lining is often subjected in ordinary railway tunnels will be amused to contemplate the task of maintaining a lining in swelling shale, for example, in a tunnel 120 ft. wide and 150 ft. high.

Still again, the Isthmian Canal Commission has made it pretty clear that earthquake shocks are to be frequently expected on any canal route located anywhere in Central America. Perhaps, by good fortune, the rocks that earthquakes would probably shake down from the roof of such a tunnel might miss hitting any passing vessel, and they might not be so large in mass as to entirely block the tunnel. Even a moderate sized rock fragment falling to the bottom, however, would be apt to sink the first vessel that came along, and we leave it to the Mandinga promoters to estimate how long their canal would be closed to navigation while a sunken ship was being raised and hauled out from the middle of a four-mile tunnel! No; the Senate and the country may as well make up its mind that it must be a choice between Nicaragua and Panama; and the sooner the remaining unknown quantities regarding the two are settled and the choice made, the better. As matters now stand, a very small thing is likely to turn the scale in either direction. A straight-out offer, either from Colombia or from Nicaragua and Costa Rica, to grant for a modest sum all that the United States requires would not be at all unlikely to bring about a prompt decision in favor of one or the other. As for the relative merits of the two routes, we can add nothing to what we have already said, except that those who at present argue for either one as the "only" route, prove only their ignorance of the subject.

A conspicuous instance of this ignorance is found in certain English journals, who have "discovered" that the Isthmian Canal Commission business was just a shrewd Yankee bluff game, put up by the United States to beat down the Frenchmen's price for Panama. One could almost wish that the final choice would be in favor of Nicaragua, just to prove to these supercilious European critics that the United States does not conduct its international business on lines of deceit. We can build as good a canal at Nicaragua as at Panama; although it will cost a greater sum to make and to maintain. If we choose the Panama route instead and pay the Frenchmen for all that their work already done will save us from expending, we are doing all that the highest standard of morals or courtesy can require.

The highest earth dam in the world, so far as we can learn, is located in Druid Hill Park, Baltimore, and forms a storage reservoir for that city. The maximum height of the dam is 118 ft. 8 ins. from the rock underlying the heart wall to the crest of the dam. The extreme height above the natural ground surface is 100.33 ft., and the water surface is 95.33 ft. above the intersection of the lower slope and the natural ground level. An illustrated description of this dam, and of the unusual plan followed in its construction, is given elsewhere in this issue. The dam and reservoir have been in service for thirty years, with, to quote from Mr. Quick's article, "no evidences of a leak through the embankment and no repairs." The structure is of peculiar interest at this time, on account of the proposed changes in the north section of the New Croton Dam, and of the general discussion of high earth dams which has followed the report of the Board of Engineers (see Eng. News, Nov. 28, 1901, and later). We also print in this issue a letter by Mr. E. Sherman Gould, M. Am. Soc. C. E., on "The Limiting Height of Earth Dams," in which he, like others, assumes 70 ft. as the maximum height yet attained by such structures, measuring the distance between the elevation of the water surface and the intersection of the outer slope with the natural ground surface. The Druid Lake Dam, as we have already stated, is 95.33 ft. between those points. Nevertheless, it has stood intact for thirty years. The methods of construction at Baltimore, however, were unusual, as is also the flatness of the slopes of the dam. Nevertheless, they appear to show that it is a physical possibility to build earth dams with safety to a greater height than is commonly assumed as a prudent limit.

The newspaper press of New York has recently given publicity to various reports of greater or less accuracy as to the views of Commissioner Lindenthal, of the Department of Bridges, upon the double-decking of the old Brooklyn Bridge. The mistake made in most of these reports is the assumption that this work—if undertaken at all—is to be done at once. Any such increase in the roadway capacity of the old Brooklyn Bridge is out of the question, says Mr. Lindenthal, in answer to a query from this journal, until at least one, and perhaps two, additional bridges shall have been completed and opened to traffic. The public does not realize what it would mean to double-deck this structure. While the old anchorages, towers and cables would be utilized, the existing stiffening trusses, floor construction, etc., would have to be replaced throughout. A variety of plans for reconstruction are feasible; but the plan adopted should aim to reduce the load on top of the towers below that now imposed upon them. Mr. Lindenthal says that, some years ago, he made studies and sketches which convinced him that a double-deck structure was feasible at this point; and he feels confident that—at the proper time—competitive plans to meet a given set of conditions, will prove the practicability of reconstruction. All of the new East River bridges will have double-decks, and thus larger transportation capacity than the old Brooklyn Bridge. The travel on the latter will never be less in the future; and the removal of the trolley tracks from the roadway, where they now impede ordinary vehicle traffic, is feasible only with a double-deck construction.

The recent serious injury of passengers at the Manhattan terminal of the Brooklyn Bridge has caused renewed public agitation over the need of prompt action to relieve the present situation. The crowding at the bridge entrance has long been indecent and disgraceful. It has now become dangerous. As we pointed out in detail in our issues of April 11 and Oct. 17, the only adequate plan of relief must provide for the extension of the car lines crossing the bridge, so as to land passengers nearer their destination. The Center St. and Park Row extensions recommended by the Board of Expert Engineers last October will give the desired relief; and we see no hope for an adequate measure of benefit from any less radical plan. Unfortunately, the Park Row extensions would pass the offices of great and influential newspapers, which naturally oppose the erection of elevated structures before their doors; but the Center St. extension is likely to be built, and the sooner the better. Meanwhile, as a measure of immediate relief we have seen no better proposal than that made by a correspondent in this issue. During the two evening rush hours, he suggests that vehicles be excluded from the bridge roadways entirely, thus enabling the number of cars using these roadways to be increased and the area of the roadways at the Manhattan terminal to be added to that available for the crowd.

The state engineer of New York wants the state to borrow $10,000,000 to expend on road improvement, and a state good roads convention wants this amount doubled. Fortunately, by the constitution of New York, the state cannot issue bonds in excess of $1,000,000 for any purpose unless

the issue is first approved by popular vote, and the taxpayers are not likely to favor any such increase in the state debt. As we have frequently pointed out, it is unsafe financiering to undertake any general scheme of road improvement on borrowed money. Stone roads return no revenue which can be used to meet the interest on the debt or to pay the principal as it falls due. On the contrary, they subject the taxpayers to a much larger burden for their maintenance than the dirt roads which they replace. In suburban sections they may, it is true, increase the value of real estate, but for such improvements the sections benefited, and not the taxpayers of an entire state, should bear the burden.

As was admirably pointed out by Prof. I. O. Baker, in his paper published in our issue of Feb. 6, stone roads in farming districts are to be considered as a comfort or a luxury; not as a revenue-paying investment. Comforts and luxuries are admirable things when one can afford them; but to borrow money for their purchase is to mortgage the future for the sake of the present.

An amusing example of the manner in which city officers are frequently loaded down with multifarious duties is furnished by an ordinance of the city of Aledo, Ill., creating the office of Superintendent of Water Works. It is made the duty of this official to:

Have charge of the water-works system; keep a complete and accurate record of all parties receiving water from same; collect all water rents and file with the City Clerk, at the end of each month, an itemized report of same to the City Council; he shall be collector of poll tax for the city of Aledo; he shall have charge of all parks, subject to the direction of the Park Committee, and shall be and have the authority of a police officer, and shall exercise all the power conferred upon a police officer by the ordinances, and shall supervise the streets.

For these services he is to receive the princely salary of $30 per month. It is fair to add, however, that the population of Aledo is only 2,000.

"Harness" is not commonly included among the list of materials and supplies with which the engineer is concerned. We notice, however, that the Sanitary District of Chicago is now advertising for "Proposals for the Harness of the Water-Power Plant at the Controlling Works near Lockport, Ill." It might reasonably be supposed that the "harness" of a water-power plant would be the parts confining the moving water and directing its energy to the point of utilization; or, in other words, that the "harness" would include first of all the turbines. We find on inquiry, however, that in this case the term is used only for the power-transmission machinery from the turbines to the generators. We fail to see the necessity for adding such a term to engineering nomenclature.

The article on a new method of testing fireproof wood which is contributed by Prof. Ira H. Woolson, M. Am. Soc. M. E., of Columbia University, to this issue of Engineering News, merits careful study by engineers and architects. In this article Prof. Woolson describes the three methods of testing fireproof wood which are now practiced and shows why none of these tests is capable of giving reliable and concordant results. The second part of the article is devoted to the description of a method of testing fireproof wood devised by Prof. Woolson himself and designed to do away with the most serious objections urged against the tests now commonly used. For the present the arguments presented by Prof. Woolson in support of his own method of testing and against the other methods which he describes, can well be left to speak for themselves. One conclusion, however, is obvious, and it is that much remains to be done to place any of the tests on a basis of accuracy which will enable the general practitioner to utilize them in his daily work and to apply the results obtained with fairness to both the user and the producer of fireproof wood. Another fact of particular importance which is brought out by Prof. Woolson's paper, is that the efficiency and availability of fireproof wood for general fireproof building work does not by any means begin and end with the mere determination of the fire resisting qualities of that material. Whether the chemical treatment of fireproofing the wood seriously injures its strength, appearance and working qualities; whether the chemicals used will have an injurious effect upon nails, screws and metal fittings which must necessarily be used in connection with the woodwork of buildings, and whether the chemicals used are permanent or will evaporate in time or will give off in case of fire noxious fumes injurious to firemen, are all questions to which definite answers are exceedingly important and to which no very trustworthy answers have yet been made. These are all matters which should be possible of easy determination, however, and all that need be done here is to remind users of fireproof wood not to overlook them. In conclusion we may call attention to one very important assertion made by Prof. Woolson, which is: That regular tests of fireproof wood are even more necessary for maintaining a standard quality than are regular tests of iron, steel or cement. This fact has, we imagine, not been generally recognized, and it is of the utmost importance to have it asserted in such unequivocal terms as are used by Prof. Woolson.

CONCERNING THE DESIGN OF EARTH DAMS AND RESERVOIR EMBANKMENTS.

Not for years has anything set engineers thinking about the subject placed at the head of this article as has the recent discussion concerning the design of the great Cornell dam and the Jerome Park reservoir for the water supply of New York city.

We have given large space to the various official reports upon these structures, not alone for the interest attaching to the works themselves, but because the questions brought forward are of importance to all engineers engaged in the design and construction of earth dams and reservoir embankments, great or small.

It is sometimes thought that the earth dam is a cheap and crude type of construction. Cheap it doubtless is, and it may be or may not be crudely constructed; but certainly no type of structure that man builds to confine water can compare in permanence with the earth embankment. Wood decays and metal corrodes. Stone, in a longer or shorter time, crumbles under the action of the weather. Earth, however, has already experienced all the changes that the gnawing tooth of time can bring. It cannot disintegrate for it is already disintegrated. Temperature stresses, which cause the engineer so much anxiety in other structures, have no terrors for the earth embankment. The only dangers to which it is subject are overtopping by floods, saturation of the mass by water until the whole yields like a semi-liquid to the pressure behind it, and erosion of the side slopes.

The most important question for the engineer in connection with the design of an earth dam is, how shall it be made water tight? All kinds of earth are more or less permeable to water. Through gravel water flows rapidly, through sand a steady flow also occurs at a rate depending on the degree of fineness and the percentage of voids. It is only earths containing clay or vegetable loam which have the property of checking the passage of water so greatly that the flow through them is practically nothing.

To build an earth dam, therefore, the engineer selects from the earths available near the site those of the most clayey character and places them in the center of the bank to form a "puddle core," depositing them in water and compacting them in various ways to obtain the most water-type construction possible. This central core forms really the water-tight part of the dam, all the rest is simply to support the puddle core in sustaining the pressure of water against it.

As our readers are aware, this type of earth dam is the standard construction of English engineers. In America, however, it has become common practice to build a masonry core wall in the center of earth dams and reservoir embankments. How this difference in practice originated, we cannot say; but it may be conjectured that geological differences had something to do with it. Possibly a greater abundance of good puddle clay in England and difficulty in obtaining clay at many places in the United States led American engineers to adopt masonry core walls to eke out deficiency in material for a puddle core. Be that as it may, a question which is now brought forward is: What is the office and purpose of the masonry core wall? Is it meant to be a water-tight curtain in the center of the dam? If so, then it must be conceded that it is far from perfect. Water percolates through even the best masonry, and such rubble masonry as is laid in core walls is bound to be far from water-tight. It does not follow that it is necessarily without value. Hardly any dam of any sort is absolutely without leakage and an earth dam may stand for thousands of years even through the core wall at its center gives passage all the time to considerable quantities of water.

On the other hand, water tightness in a dam or reservoir embankment has a greater and greater value with the increasing demand for water. Most earth dams are built in connection with municipal water supplies, and the leakage from them, even though of no importance at most times, may become in exceptionally dry seasons, a very grave matter, perhaps, making a reservoir insufficient to tide over the last day or two of a drought when it would otherwise have sufficed. Engineers are justified, then, in seeking with greater care than formerly to reduce to a minimum the leakage from dams.

There is another office of the masonry core wall which is often overlooked and that is to prevent burrowing animals from penetrating the dam. Some engineers even go so far as to declare this to be the sole value of a core wall. If this were its sole purpose, however, it is absurd to make core walls of such shape and dimensions as are now used. It would answer every purpose to build a plain wall only a foot or two thick, for its stability is of course unimportant, being supported by the embankment on each side.

But suppose now that it were possible to build such a wall and to make it absolutely water-tight. Would not such a construction present advantages of excellence and cheapness over the ordinary masonry core or puddle core construction? As our readers are aware, the use of a waterproof diaphragm in connection with other types of dam* has been successfully practised during the past few years. Let us see how the same principle can be applied to earth dams.

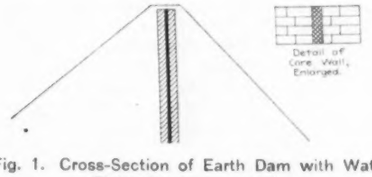


Fig. 1. Cross-Section of Earth Dam with Water Tight Diaphragm Wall.

Fig. 1 is a cross-section of an earth dam with such a core wall as is here proposed. It consists of two parallel 8-in. brick walls with an open space an inch or two wide between them which is filled as the walls are laid up with melted asphaltum, melted coal tar pitch, or other suitable permanent waterproof composition.† The brick walls themselves may be laid up with the melted asphaltum, instead of mortar, and with sound face bricks there should be no difficulty in making absolutely tight joints in this way.

Now what criticisms can be brought against such a structure? The first and most obvious one is that it would be very difficult to fill in on each side of such a high, thin wall so evenly as not to throw it out of plumb or crack it. To meet this criticism we will modify our design, as shown in Feb. 2, by increasing the thickness of the wall enough to make it stable against any unequal pressures in placing the earth filling. As we are relying on our asphalt diaphragm for water tightness, however, we need take no pains to secure tightness in the masonry on the lower side. A dry rubble backing for the brick will be not only as good but better than a wall laid up with mor-

*The steel plate dams built in recent years, most of which have been described in detail in Engineering News, may be taken as illustrations.

†So far as we are aware, no such use of an asphaltum diaphragm held in place between masonry walls has ever been made in dam construction. Such a construction was used, however, in waterproofing a subway in Massachusetts in 1896, where it was necessary to exclude water under pressure. The work was described in detail in our issue of April 5, 1900.

tar, for in case a leak should occur it is better to drain it away at once than to have it saturate the lower side of the earth embankment. On the upper side of the brick diaphragm wall, however, the engineer may give added safety by laying the masonry backing in mortar or by using concrete. In fact concrete might be used instead of brick to enclose the asphalt diaphragm, if the engineer preferred.

Again, suppose that more or less clay is available for making the fill. There is in such a case evidently no harm in placing it on the upstream

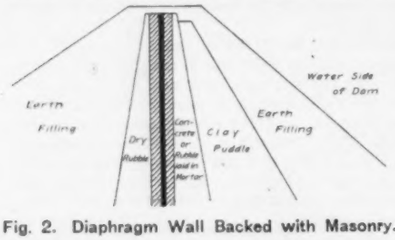


Fig. 2. Diaphragm Wall Backed with Masonry.

side of the core wall, as shown in Fig. 2, and the engineer may use more or less care in placing and puddling it according to the importance of the structure and the means available.

On the other hand, an engineer has to build dams, in all sorts of places and to meet all sorts of conditions; and while the dam shown in Fig. 2 might be worth while where the materials at hand permitted, there are, we believe, circumstances where the simple construction shown in Fig. 1—a plain brick wall supporting an asphaltum core and filled in on each side with any material available—would answer every purpose. Suppose the wall *were* thrown out of plumb a little in filling. So long as the central asphaltum diaphragm remains intact, it is not clear that any harm would be done. It will be remembered that asphaltum is a semi-fluid substance capable of yielding without cracking and certain to fill and close any crevice in the walls which confine it. There are plenty of low dams and embankments where such a cheap and simple construction would be better than the ordinary puddle or masonry core construction.

And now let us turn to the other extreme. Suppose the height and importance of the structure are such that every possible precaution must be taken to ensure its safety. Is such a type of dam as we have outlined suitable for such a location?

Of the water tightness of the asphaltum diaphragm at the outset there can be no reasonable question, provided of course that proper requirements are imposed to regulate its composition; but the question will doubtless be asked, what assurance have we that the substance will retain its properties after the lapse of many years? We can best answer this question indirectly. Engineers have in recent years made large use of asphaltum compounds for the waterproofing of such permanent structures as bridges, aqueducts, subways, and foundations, and have thereby indicated their faith in the permanence of such compounds. Certainly a layer of pure asphaltum, confined between solid brick or masonry walls and practically hermetically sealed should be at least as stable and enduring as any form of asphalt waterproofing. It is known, of course, that asphaltum does not corrode. The only change which time makes in it is through the evaporation of its more volatile constituents when exposed to the weather. With an asphaltum so compounded as to contain a minimum of these volatile consituents and then sealed from all exposure to the atmosphere, the process of change should be too slow for estimation.

Suppose, however, that the engineer has a structure so important that he deems it best not to rely on asphaltum, even when backed by masonry and clay puddle, as shown on the upper side in Fig. 2. How can additional security be afforded?

To meet this case suppose we copy the practice which has recently come into vogue in the West and make a steel plate diaphragm in our dam. We will build the structure as in Fig. 2, but in the space left for the asphalt we will build up a wall of steel sheets or plates, and we will fill in with asphaltum on each side of it as before. These steel plates buried in hermetically sealed asphaltum will be absolutely preserved from corrosion and as they are supported on each side and subjected to practically no stress they can be made as thin as desired, say ⅛-in. to 1-16-in., and the cost of such thin plates would evidently be a mere trifle in the cost of a great dam. Zinc or lead or copper or aluminum plates might be used instead, of course; but the steel buried in asphalt would probably have as long a life as any metal. If, however, the engineer is prejudiced against the use of asphalt at all, he may fill in on both sides of his plate diaphragm with cement mortar. There should certainly be no doubt as to the permanence and water tightness of such a construction.

A point of much importance in connection with the general type of construction here proposed is its use in connection with cut-off walls. It is very common in dam construction to have the part of the dam below the original surface of the ground cost as much as or even more than the part above that level. The volume of earth moved in excavating to bedrock may be as great as that in the dam itself. Now, is this method of construction absolutely necessary to a safe and substantial structure?

Suppose in the site illustrated in Fig. 3, instead of excavating a deep open pit with broad side slopes (as is necessary where the ordinary masonry core wall with its puddle backing is carried to rock), we dig instead a narrow trench with its sides sheet-piled and braced as in sewer work. When this trench is sunk to rock we will build in it a curtain wall with an asphalt core just as in Fig. 1. As the wall rises, the trench on each side of it is filled up. When the surface of the ground is reached, this cut-off wall is continued as the core wall of the dam and the earth filling on each side is made directly upon the natural surface of

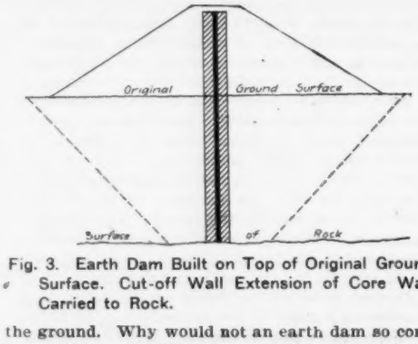


Fig. 3. Earth Dam Built on Top of Original Ground Surface. Cut-off Wall Extension of Core Wall Carried to Rock.

the ground. Why would not an earth dam so constructed be every bit as water-tight and stable as a dam built in the orthodox fashion? Of course not every site would be suitable for such a construction. The character of the earth overlying the rock and the depth of the rock beneath the natural surface will determine whether such a construction would be proper and to what degree it would be advantageous.

We have said little thus far concerning the cheapness of the construction here proposed compared with the standard construction for earth dams, but the matter is one that the engineer will surely not lose sight of. Compare the cost of, say 8 ft. in thickness of rubble masonry on the one hand and a 16-in. brick wall with an inch or two in thickness of asphaltum on the other. Again, consider that when absolute water tightness is secured in the core wall, the rest of the dam may be built up about as it happens, dumped from carts or cableways or cars, or hydraulicked into place. Further, any material available may be used; rock, sand or gravel, will answer every purpose where earth is not to be had, as happens in some localities. When it is possible to use the material closest at hand and to deposit it in any fashion, the cost per cubic yard would be greatly reduced compared with the cost of puddling, rolling, sorting material, etc., as is necessary in ordinary earth dam construction.

It is on security and tightness rather than on economy, however, that the chief claim to such a construction as is here proposed seems to us to rest. Instead of making a puddle core or a masonry core of doubtful tightness, let us make a core wall that will be really and absolutely tight. We have here suggested one way of doing this, but doubtless others will occur to our readers, and it is the general principle rather than the particular method of carrying it out on which we would lay stress.

There appears to be a tendency to fix some arbitrary limit of height for earth dams and to prefer other forms of construction for all dams of greater height. We can see no warrant for such a limitation. With the type of construction here suggested, we see no reason why an earth dam should not be feasible for as great heights as those reached by masonry dams. We are not arguing, of course, in favor of earth dams as compared with masonry. Every engineer knows that local conditions may favor either the one or the other type. What we do argue is that where conditions do favor the earth dam the engineer should not hesitate to adopt it, no matter what its height; and we trust we have shown that it is well within the resources of engineering to make such a structure as safe and secure as any that the hand of man rears.

LETTERS TO THE EDITOR.

Approximate Formula for Finding the Area of a Circular Segment.

Sir: In your issue of Feb. 6 appears an approximate formula by Mr. Wm. F. Martin for finding the area of a circular segment. I have used the following:

Let c = length of chord.
" h = height of segment.

$$\text{Area} = \frac{2hc}{3} + \frac{h^3}{2c}.$$

While this, perhaps, may not be quite as accurate as the formula given by Mr. Martin, it is sufficiently so for many purposes. Yours truly,

James Knapp Wilkes.

Annapolis, Md., Feb. 10, 1902.

Another Short Cut for Flat Right Triangles.

Sir: The short cut formula for flat right triangles given in Engineering News of Feb. 6 by Mr. John P. Brooks suggests another one which is very similar, but which holds good for all right triangles:

$$z - y = \frac{x^2}{z+y}, \text{ or } \sqrt{(z-y)\times(z+y)} = x.$$

Example: z = 29, y = 21. Required x.

$$\sqrt{8\times 50} = 20, = x.$$

This particular triangle is convenient for laying out right angles, using the 29, 50 and 70-ft. mark on the tape line.

Very truly, C. H. Gillett.

Appleton, Wis., Feb. 10, 1902.

Monolithic Concrete Sewer Construction.

Sir: I have just read with much interest the description of the concrete sewer construction at Coldwater, Mich., in your issue of Jan. 30. The writer states that "so far as he knows, it is the first one of its design ever built." With that introduction, I was led to believe that the advantages of the special design would be at once apparent, or would be pointed out and emphasized. This belief was not well founded, however. What is the special advantage to be gained from molding the concrete into blocks and then placing them in the sewer ring with mortar joints? Why not build the arch in place, as was done with the invert? The experience of the writer leads him to believe that monolithic construction throughout has much to commend it, both as regards cheapness of execution and expedition of the work of construction.

The main outlet sewer designed to drain the site of the Chicago clearing yards is of monolithic construction and of the following dimensions: 36-in. diameter, 8-in. wall 4,000 ft.; 42-in. diameter, 8-in. wall, 2,660 ft.; 48-in. diameter, 8-in. wall, 4,540 ft.; 84-in. diameter, 12-in. wall 1,000 ft.; 90-in. diameter, 12-in. wall, 5,400 ft.

For the 90-in. and 84-in. sewer the trench averaged about 24 ft. deep, and for the 48, 42 and 36-in. sizes the average depth was about 11 ft.

This work was nearly all done under the supervision of the writer, then Principal Assistant to Mr. A. W. Swanitz, Chief Engineer of the Chicago Transfer & Clearing Co. The invert was built practically as at Coldwater, except as to the detail in insuring true form and grade. The centering for the arch consisted of ribs, circular in form and resting on the finished invert, supporting a lagging made of 2 × 4-in. stuff, with edges planed to radial lines. The concrete was deposited in place and tamped as in ordinary work, except that especial care was exercised by the inspector to see that this process was not slighted. Proper thickness of wall was secured by use of templets.

The writer is now preparing an article describing this

work for the forthcoming volume of the "Transactions of the Association of Civil Engineers of Cornell University." The matter may be of some interest from the fact that a slag cement was used in the construction.

Yours truly,
E. J. McCaustland,
Assoc. Mem. Am. Soc. C. E.

Rolla, Mo., Feb. 1, 1902.

Automatic Stop Systems in Conjunction with Block Signals.

Sir: Aside from the elimination of smoke and steam, one of the chief advantages claimed by the advocates of electric traction for the Park Ave. tunnel is that the current supply may be cut off from a train running past a danger signal. These advocates seem to entirely overlook the fact that a heavy train would coast for a great distance without appreciable reduction in speed, and that an engineer so negligent or disabled as to run past the signal would in all probability fail to observe the lack of power until the speed had been much reduced.

It seems to me that with the present air brake equipment it should be a very simple matter to prevent running past signals. All that is required is a tripper along the track adapted to throw open a valve on the train pipe, this tripper to be connected with the signal lever and placed some distance beyond the point where the engineer should observe the signal, so that it would not act unless the train passed the danger limit. Has this been suggested before, and, if so, wherein is it impractical?

I have done some experimenting in connection with locomotive headlights of the Mangin lens acetylene type, and note that in emergency stops it is of the utmost importance to apply sand, and that the full effect of the brakes is not felt until after running a full train length when every wheel has sand.

Why could not sand-boxes be placed upon every car and be controlled by the action of the brakes so that on emergency application every wheel would instantly have a full supply of sand?

Yours truly,
S. W. Rushmore.

Hudson and Morris Sts., Jersey City, N. J.,
Jan. 30, 1902.

(Automatic stop systems have been in use to a limited extent for years. The Rowell-Potter system, on the Boston, Revere Beach & Lynn Ry., was described in our volume July-December, '92, p. 369. A similar system is in use on the Boston Elevated Ry. There is considerable reason to believe that for a city transit line, such as the latter, the system is advantageous. For the main line railway service, however, signal engineers generally are not yet convinced that the system is on the whole safer than the ordinary block system.—Ed.)

A Remedy for the Evening Crush at the New York End of the Brooklyn Bridge.

Sir: In consequence of the inadequate number of cars during the greatest evening traffic over the Brooklyn Bridge, there accumulate crowds of waiting passengers at its New York end. These, in their struggle for seats in the cars, cause the crushes. An adequate number of cars at regular intervals will alone remedy this evil. To provide these it is necessary to exclude the wagon traffic on the roadways during at most two hours on weekday evenings. This will permit an increase in the speed of the cars of at least 50%, which would give 50% more cars, with the same distance between them. With the wagon traffic excluded, a shorter space interval between cars is, however, unobjectionable. It would therefore be possible to send safely twice the present largest number of cars per hour over the bridge and to make them pass the New York loops at quite regular intervals. With no wagons during the two hours of heaviest traffic, the space available at the New York end for loading and unloading would be increased by the area of the two roadways and an arrangement for taking care of the greater number of cars in the much enlarged available space would be not such a difficult problem as at present. It is quite possible that experience would show the present facilities adequate for some time if a sufficient number of cars would pass the New York loops at regular intervals. This could easily be tested without much expense.

An incidental advantage of this change would be a material time saving to the passengers. An increased traffic by surface cars would be the consequence. Changes in the New York loops would therefore probably be ultimately necessary. More car lines near the Brooklyn end of the bridge would be another necessary change. The most serious drawback to this solution is the fact that the wagon ways are most used during the morning and evening hours, and the teamsters would be much inconvenienced by being shut out from the bridge when they most want to use it. The city, however, must remove the present dangerous crushes at the New York end of the bridge, and if no other solution is possible, the teamsters must be otherwise provided for. If they have a right to the gratuitous use of the bridge or equal facilities, then the city might find it judicious to provide free ferry facilities for them during the hours they are shut out from the bridge. The importance of providing immediately for the safety of the passengers is so great that some inconvenience must be borne during the time which is necessary to provide a complete remedy. The city has undoubtedly the power so to regulate the bridge traffic that the amount of inconvenience is the least possible, which is not the case at present. It has been proposed to exclude wagons from the car tracks by a curb. This would greatly impede the wagon traffic, not only for two hours, but during the whole day, and it would leave the available space for loading and unloading the cars at the New York end unchanged. A larger passenger traffic than at present could undoubtedly be accommodated, but not as large a traffic as with the complete exclusion of wagons for two hours.

At present probably 40,000 passengers per day are inconvenienced or endangered. The change proposed might necessitate the deflection of 2,000 wagons daily to the ferries or their choice of another hour for crossing the bridge.

Joseph Mayer.

No. 1 Broadway, New York, Feb. 11, 1902.

The Design of Angle-Bars.

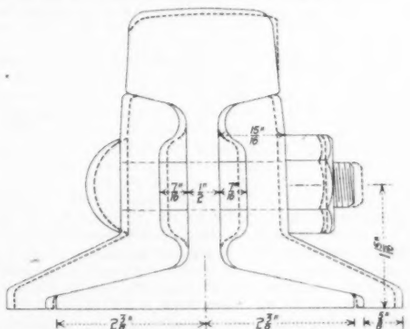
Sir: In your issue of Jan. 23 Assistant Engineer Wendt, of the P. & L. E. Ry., shows section of rail splice taken out of track after ten years' service, and remarks that "the defect in the design of the angle-bar is obvious." As there are several features of the design that are open to objections, the writer would be pleased to know which is *the* defect to which he refers.

H. V. Hinckley, M. Am. Soc. C. E.

Topeka, Kan., Jan. 27, 1902.

(Proof of the above letter was submitted to Mr. Wendt, and we append his letter, reproducing also the cut which appeared with his original contribution.—Ed.)

Sir: It is only fair to state that it was not our purpose to condemn the angle-bars in question, but rather to call attention to the fact that the inner projections might have been designed with different radii so as to have given the bar a longer life under wear and at the same time not have reduced the bearing area of the upper side of the bar. I have written Mr. Hinckley to this effect.



Standard Section of 71-lb. Rail and 24-in. Angle Bar of Pittsburg & Lake Erie R. R., for 1892 and Previous; and Section Removed after Ten Years' Service (Indicated by Dotted Outlines).

The strongest criticism of my opinion of this bar has been made by Mr. Thomas H. Johnson, Consulting Engineer of the Pennsylvania Lines West of Pittsburg. On Jan. 24 he wrote to me as follows:

The inference is that the bearing surfaces had worn until by repeated tightening the angle-bars were brought into contact with the web of the rail, and that the projections on the inner side of the bar should either be omitted or reduced in size to allow further tightening of the bolts.

These projections are very necessary in obtaining the requisite moment of inertia in the bar, and before condemning them it will be interesting to know whether you have found the condition shown in your diagram to prevail generally in your tracks, or if it is only exceptional.

Also have you record evidence that the rails and angle-bars when rolled strictly conformed to the theoretical templates with which you are now comparing the present conditions?

In our experience this perfect conformity to templates is not always obtained without close and careful inspection at the mills.

I have written Mr. Johnson to the effect that his inference as to our criticism was correct.

No doubt these projections are necessary, but their size and shape could be modified. We regret that the inspection of our rails and angle-bars ten years ago, when those now in question were rolled, was rather loose, and we do not have any record evidence that said rails and angle-bars conform strictly to the theoretical templates. We believe that all rails and angle-bars should be carefully inspected in order that bars may fit the rail perfectly; otherwise the best line and surface will not be obtained.

Yours truly,
Edwin F. Wendt,
Asst. Engr., P. & L. E. R. R.

Pittsburg, Pa., Feb. 3, 1902.

Wanted—Literature for Young Engineers.

Sir: For several years past the conviction has grown stronger and stronger in the mind of the writer that a truly "long-felt want" is more literature for young engineers, yet, so far as he knows, the want is as far from being filled as it was when his attention was first drawn to the scarcity of engineering news of real benefit to the younger members of the profession.

True it is that there are published several engineering magazines, each excellent in its way, and these are supplemented by the proceedings and transactions of the different engineering societies, but still the writer does not think that the young engineer gets a sufficiency of the kind of reading and information that is calculated to do him the greatest amount of good.

Each engineering magazine, each engineering society likes to exploit unique and unusual engineering achievements, and therein, to a great extent, lies the whole trouble; yet, generally speaking, we can attach no blame either to magazine or society for wishing to set forth the manner in which some difficult or gigantic engineering problem was, or is to be, solved.

The truth is, however, that the young engineer has troubles of his own, which, while infinitesimal perhaps, to older and better trained minds, seem, nevertheless, stupendous to him, and, while reading of these monster works of other hands is extremely interesting, it does not help him with his present problems, and the chances are that it will be some years at least before he is called upon to cope with circumstances such as have been described at length in his latest scientific publication.

A certain amount of information and knowledge is to be obtained from text-books, and it is assumed that this is learned, to a greater or less extent, at college; but there are hundreds of little details, "schemes," "cut-offs," etc., that never have been and never will be incorporated in any text-book. They must be learned while the engineer is in the practice of his profession, and it is in disseminating such bits of information that an engineering publication can accomplish its greatest good, and it must, or should, at all times remember that what may be threshed out straw to the older men is new wheat to the younger ones, and it should, to fulfil its mission, publish what the younger men want and need, even though the older ones may pass these little things by with a smile of pity at the ignorance which finds interest or instruction in them.

It is the knowledge of little things which helps an engineer in his work, and, sad to say, these same little things are the hardest to acquire, at least that has been the experience of the writer. The big ones come from the text-books, the little ones, the details, come only with experience, and, as a general thing, they come slowly. It is therefore patent that any literature which will aid in the acquisition of these will be heartily welcomed.

The production of such literature is a burden equally placed upon the shoulders of the engineers and the publishers of the engineering journals of to-day, and whether or no either will care to assume his share of the load is a question yet to be answered. The material must, for almost the entire part, be furnished by the engineers. The dissemination of this material lies with the publisher. Whether the latter will think it worth while to print matter already known to older readers is another unsolved problem.

From all the writer has observed, he feels safe in saying that, to the young engineer, the most interesting and instructive portions of the technical journals come under the captions "Questions and Answers," "Notes and Queries," "Letters to the Editor," etc. You may change these titles to fit the different publications, but their import remains the same. In these departments the reader finds questions and answers pertaining strictly, as a rule, to the little details of engineering work, and also he finds brief, perhaps, yet complete descriptions of interesting facts that have come under the notice of brother engineers. These are the things that help. The young engineer may be interested in an extensive and profound dissertation upon the changing of the course of the Gulf Stream, but the chances are that he will not be employed on such a job very soon and that in the meantime he would derive more actual benefit from a 20-line article telling of some little problem that had been solved by a method easier than the one in general use, or some little pit-fall into which an engineer is liable to fall and how to avoid it.

As has been said above, the older readers would probably pass such by with a pitying smile, but not so with the younger ones. The time may come, perhaps, when they, too, will do likewise, but even then these selfsame little items will still be the "news" to those who are at that time the "younger" ones.

Every railroad, every bridge company, every shop has methods peculiar to itself of doing the same thing, and an interchange of these methods cannot but be of benefit to the mind of the engineer who does not wish to get into a rut and to do the same old thing in the same old way "just because we've always done it that way."

The writer firmly believes that the publishers of the engineering journals will do their full part in what can be made a most important work, and it then rests with the engineers, young and old alike, to give to others the benefit of their knowledge and observation of what may seem, at

first blush, to be trivial matters, but which will, in the majority of cases, prove to be interesting, instructive and appreciated literature for young engineers.

Arch. R. Eldridge, M. Am. Soc. C. E.

Chicago, Ill., Jan. 14, 1902.

(We give space with great pleasure to the above communication, because it is wholly in accord with the ideas that have long been held by the editors of this journal. We can assure our correspondent, and every reader and potential contributor to our columns, that no articles offered for publication find here a more hearty welcome and a more prompt publication than the brief descriptions of "how to do things" to which our correspondent refers.

We are not so much concerned to make Engineering News *interesting* to our readers, even, as we are to make it practically *useful*, and useful to the young and active workers in the field, the shop and the office, rather than to the graybeards.

On the other hand, it is perhaps well to explain that an engineering journal must supplement—as our correspondent indicates—and not replace the text-books. The demands on our space do not permit the republication of matter which can be readily found in standard books of reference. It is the things which have been developed since the text-books were written, and the things that the text-book writers overlook, that we particularly desire to publish.

Perhaps this is a good opportunity, also, to refer to what is perhaps the greatest fault in engineering literature to-day. It is too much devoted to the description of things, and far too meager in its presentation of problems and their solution. Let us try and make the distinction clearer. A certain locomotive has been built, let us say, and the firm building it furnishes us with drawings and a stereotyped description, including a table of its principal dimensions. We publish it, very likely, in the absence of anything better. Suppose, on the other hand, the man responsible for the design of that locomotive sits down and tells a story of a different sort. The locomotive, it appears, follows ordinary practice in its design, except in its firebox. It was desired to use a certain kind of coal, which gave trouble in certain specified ways, and the problem was, how to make a firebox to burn this coal; and then he tells us in detail how the peculiar shape or size of the firebox was developed, keeping in mind all the time that only that part of the problem's solution is worth record in technical literature which will be practically useful to his brother engineer who has a similar problem to solve.

That, in a nutshell, is our idea of the most useful class of technical literature; and contributions on these lines always find a welcome in these columns.—Ed.)

Experience with Grouted Masonry—The Efficiency of Masons.

Sir: The writer has been much interested in the opinions advanced by several writers in your columns as to the efficiency of grouted masonry.

From an experience of 35 years, grouted masonry cannot be claimed to be a perfect success. The writer has had occasion several times to take down masonry previously built by himself, as well as that built by others, which was supposed at the time to have been properly grouted, and he has found many cavities under and around the stones, showing that the grout did not fill at all places. As a result of this experience, all his specifications for some years have contained a clause similar to the following:

> Rubble stone masonry will be made of irregular shaped stone, laid in cement mortar. While the stone may be of such size as the contractor desires, within the limits of the structure to be built, each stone shall have one good even bed and all sharp or feather edges shall be spalled off, and the top of the stone as laid shall not overhang the bed. Care must be taken that each stone is entirely surrounded by mortar. Spalls may be used to fill in between the larger stone. All stone, whatever the size or shape, *shall be placed in or upon a bed of mortar.* All stone shall be solidly rammed to a firm and uniform bearing.

Engineers of experience will remember that in laying dimension stone masonry, where the stone is laid on a bed of mortar and with vertical joints of a half-inch or so, when an attempt is made to grout the vertical joints it is necessary to work the cement grout down by the use of a tool having a thin blade, and even when the joint is apparently filled there is found room for more g out after the first filling has been worked by the thin bladed tool. It is probable that air had been trapped in places and the stirring is necessary to liberate it. If this occurs with a joint in its best form, how much more likely is it to occur in the irregular joint of rubble masonry?

Again, in all vertical joints of considerable height the grout will be stratified. The stratification will be the more noticeable with the lighter cement.

Your readers have undoubtedly, for various reasons, required a stone which the mason had supposed to be permanently placed to be lifted and upon examination of the mortar and the under side of the stone found places where mortar had never touched the stone, indicating voids. The space underneath a large stone is not entirely filled with grout from several causes. If the grout is mixed with an insufficient quantity of water, the grout will flow but a comparatively short distance along the horizontal joint, and the point of entrance is closed and the weight due to the usual height of a joint will not be enough to force more grout through. If the grout is mixed very thin, the excess water will fill a space that afterwards becomes voids.

No masonry is built without a quantity of dirt being brought in on the stones by the masons' feet, and the tramping on half-set mortar, which soon becomes dirt. As considerable time usually elapses between the placing of the first stone and the grouting, this dirt to a large extent finds its way into the vertical and horizontal joints and forms little dams here and there, around or through which the grout cannot force its way. The result is a cavity beyond and an imperfect masonry structure. Dirt, as used above, is understood to be "matter in the wrong place."

As another illustration, let the reader remember how difficult it is to make perfectly solid concrete. One would suppose small stone, sand and cement, carefully mixed and placed in thin layers and well rammed, would be as compact as it would be possible to make. How often, however, when the forms are removed and the concrete examined, cavities appear with the stones touching but almost no mortar between.

As to the efficiency of masons (Eng. News, Jan. 23 and Feb. 6), the writer is inclined to side with Mr. Hay, although he has never determined the relative efficiency of the several classes of mechanics. Mr. Taylor says:

> The young engineer should rather believe that his duties are to help the work forward and to give instructions to men more ignorant than himself in the best ways of doing things.

Now, did Mr. Taylor ever find a man sufficiently handy with a trowel to be called a mason that would admit "the young engineer" could teach him anything, or did not think he knew more about the laying of a stone than the "young engineer," or, in fact, the Chief himself? Herein is a part of the reason for the inefficiency of the mason. The large majority of masons have never had experience on work of such importance that the placing of each stone was vital to the structure. The ordinary mason is one who probably began by laying first walls of dry stone and next the ordinary house wall, where a trowel of mortar answered for the bed and to hold the stone steady until the next one was laid and one or more trowels of mortar was placed along the tops of the vertical joints, mainly for look's sake.

When such a man is employed on a dam, what does he know of tight, solid work? At the same time, if he has had two or more season's experience, he will not admit but that he knows more than the whole corps of engineers, men who never held a trowel. When a man, no matter what his line of work, thinks he knows it all, he will insist on his own way, right or wrong; and engineers will find a faithful inspector necessary for each gang of masons.

Last summer the writer had occasion to contract for the building of a masonry dam about 30 ft. high above the bedrock. Care was taken by the assistant engineer in charge, as well as myself, to caution each bidder that the dam must be made tight and every joint fully filled with mortar, and that an inspector would see that the work was done in full compliance with the specifications. The contract was let to a contractor of experience, who supposedly knew what tight work required. Fortunately for the dam structure, work was first begun under the contract for the building of a small receiving well, which was required to be water tight.

The contractor brought to the work some Italian masons and filled up the balance of his gang with local American masons. At first the American masons were placed at points of most importance, but it was soon found they could not properly build a vertical wall, nor could they be made to see the importance of filling the joints with mortar. The Italian masons, probably not having so high an opinion of themselves, would try to do as they were told, and as a result the contractor changed the position of the two sets of masons, giving the Italians the position of most responsibility. After the work had been going on for a few weeks, the contractor began to complain that we were requiring more mortar and much better work than he had bid upon, and made all sorts of claims that the work would hold water, etc. Here the contractor was on the side of the mason. The contractor was convinced, however, that the engineers were within the specifications, and directed his men to do the work as required.

Soon after the work began on the dam we had a heavy rainstorm, which flooded around the receiving well, so that all hands had a practical example as to the water tightness of the masonry they had built, and were astonished at the amount of water coming through the wall. The part of the wall built by the Italians goes's was nearly tight, but that part built by the Americans was far from tight.

The mason usually does not see his work [illegible] but in this case he did, and we have no doubt the [illegible] will be better for it, for the inspector has had [illegible] trouble since. At the same time, the masons still require watching.

It must be remembered that the object the contractor has in view is the profit on the work, and the means quantity of work done by each man employed the less the efficiency, in the sense of good work, the greater the quantity. The less mortar used, the less time required to place a certain quantity of masonry, and as the probability of employment for the mason depends largely upon the *quantity* of work done, he is inclined to make the best showing for himself, knowing he will receive his pay every two weeks and that he cannot be reached even if the structure does not hold water. The mason leaves it for the engineer and contractor to fight it out and pay the cost—the engineer in loss of reputation, the contractor in loss of money.

James H. Harlow,
Pres. and Ch. Engr. Penn. Water Co.

Wilkinsburg, Pa., Feb. 12, 1902.

Time as it Affects the Selection of an Isthmian Canal Route.

Sir: Since the recent report of the Isthmian Canal Commission, in which the offer of the Panama Canal Company to sell its rights and franchises to the United States Government for $40,000,000 was considered, it has been currently reported that the Colombian Government could not or would not furnish a lease to the United States in perpetuity, but would grant to the United States certain privileges, which might or might not be sufficient, for an annual rental of from $1,000,000 to $1,500,000.

The Isthmian Canal Commission has estimated that the annual cost of maintaining and operating the Nicaragua Canal would be $1,300,000 greater than the corresponding charges for the Panama Canal. It would seem fair to presume that the cost of rental, if the Panama route should be selected, would about equal the additional cost of maintenance that would have to be met in the event of the selection of the Nicaragua route. Especially is this the case when we take into consideration the fact that it is believed that the westward drift of sand in the vicinity of Greytown Harbor is diminishing and may in time become quite small, which would, of course, tend to decrease the cost of maintenance on the Nicaragua route.

If the Panama route should be selected, in addition to the amount paid to Colombia for annual rental, the United States would have to purchase the 1,137 shares of stock in the Panama Railroad which are now owned by private individuals and not included in the Panama Canal Company's offer, and should also take into consideration the fact that in about the year 1924 the Alhajuela Reservoir would have to be constructed in order to accommodate the estimated increase in traffic. The estimated capacity of the Panama Canal as at present designed and described in the Commission's report is 10,000,000 tons annually, and from the same report we get 10,500,000 tons as the probable tonnage for the year 1924. In the case of the Nicaragua route, we have a natural reservoir (Lake Nicaragua), which is about 5,000 sq. miles in extent. This area would be very materially increased by the construction of the Conchudo dam.

Thus it appears that in the event of the selection of the Panama route, the expenditures for necessary rights and privileges not included in the Panama Canal Company's offer, and for additional works that would probably be necessary in the near future, would exceed the amount of $1,500,000 that is charged against the Nicaragua route on account of excess in cost of annual maintenance and operation.

Under these conditions it would seem proper to give the element of *time estimated for construction* of an Isthmian Canal more weight than has apparently been done.

In the Commission's report of November, 1901, we find the following with reference to the Nicaragua route, on page 259:

> The cut through the divide west of the lake probably will require the longest time of any single feature of construction. It contains about 18,000,000 cu. yds. of earth and rock excavation, or a little less than 10% of the total material of all classes to be removed. With adequate force and plant this Commission estimates that it can be completed in four years. This indicates, under reasonable allowance for ordinary delays, that if force and plant enough were available to secure a practically concurrent execution of all portions of work on the route, the completion of the entire work might be expected within six years after its beginning, exclusive of the two years estimated for the period of preparation.

So that it appears that the Commission estimates that it will require a period of eight years to construct the Nicaragua Canal, after the necessary rights and conces-

sions have been gotten. It will be noted that this period of eight years is 100% greater than the period estimated for the construction of that feature of the work requiring the most time.

On pages 259 and 260 of the report we find the following:

The greatest single feature of work on the Panama route is the excavation in the Culebra section, amounting to about 47,000,000 cu. yds. of hard clay, much of which is classed as soft rock, or nearly 45% of all classes of material to be removed. It is estimated that this cut can be completed in eight years, with allowance for ordinary delays, but exclusive of a two-year period for preparation and the unforeseen delays, and that the remainder of the work can be finished within the same period.

So that it appears that the Commission estimates that it will require a period of ten years to complete the Panama Canal, after the necessary rights and privileges have been gotten. The time estimated for constructing the greatest single feature on *this* work is not given *exclusive* of the ordinary delays, and hence the percentage of time allowed for preparation and delays cannot be stated.

Comparing the time estimated for the completion of a canal by the two rival routes, we have:

Panama Route—(Assuming rate of progress in controlling feature of work to be about 5,400,000 cu. yds. of excavation in hard clay and soft rock per year, with an additional allowance of 25% of time for preparation)	10 years.
Nicaragua Route—(Assuming rate of progress in controlling feature of work to be about 3,000,000 cu. yds. of excavation, largely rock, per year, with an additional allowance of 33⅓% for preparation)	8 years.
Difference in favor of Nicaragua	2 years.

No individual or corporation would undertake a work of the magnitude and character of the Isthmian Canal unless it could be satisfactorily demonstrated that the undertaking would pay at least 4% as an investment. In the case of an individual constructing the canal he would look to the tolls principally for his profits. With the United States as the builder the situation is changed considerably. In this case, in addition to the tolls collected from foreign peoples, the commercial, industrial and military advantages and also the prestige which the ownership of the canal would give to the United States as a nation, would be counted among the profits resulting from the construction of the canal. These taken together would certainly seem to be worth as much as 4% on the cost of the canal. If they are not, then we should not construct the canal by either route. If they are worth that much, then the two routes may be compared as follows:

Panama Route.		
Estimated cost of construction	$144,233,358	
For purchase of Panama Canal Co.'s interests	40,000,000	
Total		$184,233,358
Nicaragua Route.		
Estimated cost of construction	$189,864,062	
Cost of all necessary concessions	6,000,000	
Total	$195,864,062	
Deduct for profits for two years, or until date on which it is estimated that the Panama Canal could be completed and opened for traffic (2 years, at 4% per year)	15,669,125	
Excess of expenditures over receipts for Nicaragua route up to date on which Panama Canal might be opened		$180,194,937
Giving a difference in favor of Nicaragua of		$4,038,421

In the above comparison it will be noted that it is made under the assumption that either canal could be begun at once. In the case of the Nicaragua Canal this is true, since the protocol by which the treaties with Nicaragua and Costa Rica would be made has already been arranged and there are no obstacles to prevent either of these countries from entering into treaty with the United States. In the case of the Panama Canal, the United States would have to make its offer of $40,000,000 to the Panama Canal Company and the acceptance of this offer would have to be ratified by the stockholders of the company. The deed of transfer to the United States would have to be signed by the new Panama Canal Company, by the liquidator appointed by the French Government to look after the interests of the stockholders in the old company, who own about 60% of the stock in the new Panama Canal Company, and also by the Colombian Government on account of the paid-up stock that it owns in the Panama Canal Company. This transaction when closed would only secure the rights, property, etc., that the new Panama Canal Company now has. The United States would also have to treat with the Colombian Government for the additional rights that are considered to be necessary before any construction could be commenced. At present Colombia is in a state of revolution, has no Congress and consequently is not in a position to treat either with the canal company or with the United States. There is no certainty as when peace may be restored or when she will be in a position to make treaties and agreements with the United States; but it may be safely assumed that she will not be able to make a treaty with the United States during the present session of our Congress, which would mean the postponement of the commencement of the Panama Canal at least one year and it is not unlikely that it would be postponed even longer.

In the meantime the United States is losing a little more than seven and one-half millions of dollars per year on account of the delay. This would seem to the writer to be good and sufficient reason for the selection of the Nicaragua route and the beginning of construction immediately.

H. H. Trundle, M. Am. Soc. C. E.

Bond Building, Washington, D. C., January 27, 1902.

(Notwithstanding the unanimous report of the Commission, one of its members, Prof. Burr, states, in the current "Scribner's" that in his opinion it will take longer to complete the works at Nicaragua than at Panama.—Ed.)

The Limiting Height of Earth Dams.

Sir: The report of the Board of Experts upon the New Croton Dam and the various communications which have followed it have furnished as interesting matter to the water supply engineer as has, perhaps, ever appeared in your columns.

Aside from many minor points, this body of literature raises certain fundamental questions of the highest importance, which should, now that they have been presented in connection with a practical example, receive, if possible, a definite answer. As making towards this desirable end, I venture to offer the following considerations which appear to me to bear upon the subject.

Perhaps the most important of the questions raised is this: Is there a certain moderate limiting height beyond which it is not safe to build an earth dam, with or without a masonry center wall? The vital importance of this question lies in the fact that it is universally conceded that a high masonry dam should only be built upon a rock foundation. The peculiarity of the earth dam consists in the fact that it can be safely built upon almost any material, due care being taken to adapt its design and execution to the natural conditions of the site. If, then, the safety of an earth dam diminishes, from the nature of the material of which it is composed, as its height increases, and the danger line is overstepped when a certain moderate height is reached, then it is impossible to build a high dam which shall be safe except when a rock foundation can be secured upon which to raise a masonry structure.

The experts admit that up to a height of 70 ft. (counting the height as the difference of elevation between the surface of the water in the reservoir and the intersection of the outer slope of the bank with the natural surface of the ground) an earth dam may be made perfectly safe. There seems to be some difference of opinion as to the height, as above defined, of the embankment of the New Croton Dam when completed. The experts appear to put it at about 100 ft., and as my object is to consider the general problem rather than the special case of the Croton Dam, I will take it as such. At this height they consider this part of the dam to be unsafe.

How correct the view may be, which locates the danger zone within the 30 ft. difference between these two figures, has not, so far as I know, been determined by the only real test—that of actual trial—for there does not appear to be any recorded instances of earth dams 100 ft. high,* the enormous dams in India being so rather from their length than their height.

Setting aside the principal source of danger—that of being overtopped, which, if not fully provided for in the original project, can easily be by raising the crest of the bank higher than that of the adjoining masonry—the danger which the experts apprehend is from saturation of the lower side of the embankment, tending to cause it to lose consistence and "slump" away. This, of course, could not occur from water within the reservoir, unless the masonry center wall should leak badly.

When, a number of years ago, it was first intimated that well constructed earth embankments might become practically saturated with water, at least on the reservoir side, I confess to having been very sceptical of the fact, and when the investigations of that painstaking and accurate experimentalist, Mr. Desmond FitzGerald, demonstrated that in one instance at least such was the case, I concluded that the circumstances of that particular reservoir must be exceptional. In any event, my conviction of the necessity of a solidly built center wall was greatly strengthened, for it seemed to me, in the given instance, if the degree of saturation was as great as alleged, that the center wall was all that stood between that particular dam and destruction. In view, however, of repeated observations—those of the experts, among others—it seems reasonable to believe that all earth dams, with or without core walls, do actually imbibe more or less moisture on one or both of their sides. If this be so, the fact is certainly disquieting at first sight. Confidence returns, however, when we reflect upon the immense number of such dams in existence all over the world, of the destruction of which, through this cause, there is not, so far as I am aware, a single recorded instance. Such instance may, indeed, easily exist without my knowledge, but among the many recorded failures of large earth dams I believe it would be hard to find—to say the least—a single case of the actual melting away of an embankment by being gradually reduced to mud through slow absorption. Conceding the absorption, which appears to be pretty well established, one would certainly look for rather numerous instances of such failure, particularly in poorly compacted banks; but they seem obstinately to refuse to yield in this way. They yield by being overtopped, or by water following a pipe or other conduit running through them when unprovided with a masonry cut-off, but not, as far as my information goes, by general saturation. There is evidently a saving clause somewhere.

Since earth dams up to 70 ft. can be made safe against this danger, if it exists, the question then arises, is it impossible to make them so when carried, say, 30 ft. higher? The final answer to this question awaits an actual trial. In engineering no other argument is convincing. But we are permitted, and, indeed, compelled, to speculate as to the possible how and why. If saturation, partial or complete, increases with depth, then it must be due to increasing pressure. Can water be forced into a bank 500 or 600 ft. thick by any pressure? When we consider the immense resistance offered to the passage of water through the closely compacted particles of an earth bank, natural or artificial, it would seem that static pressure could not be operative beyond a very few feet in depth over the surface of contact, and certainly no pressure could be brought to bear sufficient to blow up the bank if the water was forced into its heart.

It would seem that whatever water gets into an earth bank must be introduced by simple soakage, the pressure exercising but a slight influence upon the penetration beyond a small depth. If this view be correct, then it appears reasonable to suppose that the greater the mass of earth, the less danger of its being saturated by the water, which, as the area of cross-section increases approximately as the square of the height, would lead to the conclusion that as far as soakage is concerned the higher the dam the less liability is there of general saturation. Suppose a theoretical cross-section, 10 ft. high, with slopes of 2 to 1, coming to a point at the top—that is, having a top width of zero, and sustaining water level with the top, or 10 ft. deep. The area of cross-section would be 200 sq. ft. and the bottom width 40 ft., the sloping surface in contact with the water would be about 22 ft. long. To penetrate the bank at the bottom, a given particle of water would have to travel 40 ft., and to impregnate the mass a volume of 200 cu. ft. per running foot of bank must be saturated. Now, suppose the height to be raised to 100 ft. The height, the sloping surface in contact with the water and the bottom width would be increased tenfold, but the mass would be increased a hundredfold. A given particle of water, to get through the bank, would have to travel 400 ft., instead of only 40. In actual practice the advantage of the larger mass would be increased by the greater top width which would be given to the higher dam. No account is here taken of the center wall.

I fail to find a distinct mention made of any flow of water passing under or through the lower bank. The absence of such flow indicates that there is no motion along the slope of saturation shown in the figures accompanying the experts' report. This is an important datum of the problem. In the figures showing the slope of saturation in some of the earth embankments in the Croton Valley (see Eng. News, Nov. 28, 1901—Ed.) the center wall seems to offer a surprisingly small impediment to the passage of the water. The section of the Middle Branch Dam and of the Bog Brook Dam presents the puzzling feature of the water standing higher below the center wall than above it.

It is to be feared that in many cases the masonry center walls of earth dams are built too light. They should be more than mere diaphragms; they should be *walls* in fact as well as in name. My own rule is to give the center wall a bottom thickness equal to one-quarter of the greatest depth of water in the reservoir, and to draw it in by off-sets 2 ft. in every 10 ft. of height. I would never voluntarily reduce this thickness, although I might increase it, except perhaps to draw in more rapidly near the top in the case of a very high wall.

I offer the above considerations for whatever they may be worth towards throwing light upon the following very interesting questions:

(1) What is the limiting height, if any, imposed by the nature of the material used, to which an earth dam may be safely carried?

(2) In what way, other than by overtopping, may a well constructed earth dam of any height, provided with a substantial and practically water-tight masonry center wall, be destroyed?

(3) From what different causes have earth dams been known to be destroyed?

All of the above remarks apply only to the abstract propositions involved, without reference to the concrete case of the New Croton Dam, which I have taken merely as a text.

E. Sherman Gould.

Yonkers, N. Y., Jan. 17, 1902.

*The Druid Lake Dam, connected with the water supply of Baltimore, Md., measures 95.33 ft. between the water surface and the natural ground level at the foot of the outer slope. We have held this letter, in part, in order to present a description of the dam, which will be found elsewhere in this issue.—Ed.

Notes and Queries.

A. L. H. writes:

Can you tell me if a degree of longitude has ever been measured south of the equator, and, if so, with what result?

Merriman's "Geodetic Surveying" refers to the measurement of an arc in Peru in 1736-40, and of another in South Africa by Lacaille in the latter half of the 18th century.

Our attention has been called to two typographical errors in Mr. A. W. Dow's "Criticisms of the New York Asphalt Pavement Specifications" in our issue of Feb. 6. In the opening paragraph both the old and the proposed new specifications were credited to the Engineer of the Commissioner of Accounts. The bottom line, middle column, p. 123, should read "contain on an average 60% (instead of 6%) bitumen," etc.

W. M. A. writes:

I have a contract to build a reservoir, and the specification requires the embankment to be made with carts and then rolled. A great part of the embankment could be made with wheeled scrapers, and I argue that a bank made with such scrapers, where 12 horses would tramp over the same ground in the time that one horse would in using carts, will be as solid as a bank built with carts and rolled. Scraper work being new in this locality, however, the engineer in charge insists on the use of carts, as specified. I would like opinions of your readers on this subject.

So far as moving the earth into the bank is concerned, unless the engineer wants to sort it or throw out cobbles, and wishes to use carts for that reason, we do not see why the use of wheel scrapers might not be permitted. That the use of such scrapers would make rolling unnecessary, however, is not at all clear. As shown by the articles in the present issue, building an earth bank to hold water is not a mathematical process by any means. The engineer wants to make his bank as solid as possible, and is justified in insisting on every precaution to that end which the specification calls for.

A correspondent in Kansas City recently informed us that he had heard a rumor that the Melan arch bridge in Topeka was badly cracked and was about to be abandoned. We referred the matter to Mr. H. V. Hinckley, M. Am. Soc. C. E., of Topeka, who replies that the rumor is without foundation. The bridge is as safe and sound as ever. A possible origin of the rumor is the cracks which have occurred in the concrete posts supporting the railing and in some other parts of the ornamental molded work. The posts referred to have the appearance of being thoroughly cracked and ready to drop to pieces, but the apparent cracks are black veins, which, when tested with the point of a knife, are found to be harder than a natural stone. These defects are only in the appearance of the structure therefore.

The specifications for the bridge (Eng. News, April 2, 1896) called for the molded ornamentation to have a body made of 1 cement, 3 sand and 3 small stone, with a facing ¾-in. to 1¼ ins. thick of 1 to 3 cement mortar.

Curiously enough, on the same page with an illustrated article on the completion and testing of the Topeka bridge, on p. 99 of our issue of Feb. 10, 1898, was printed the following query:

P asks: "In Portland concrete work faced with 1 to 3 or 1 to 2 mortar, or with pure cement, I find numerous hair checks; also numerous large checks which, during wet weather, make the face look as if it were of stone and were cracking all to pieces. Yet in general the checks seemed to be lines of a hard and almost black material. Are these checks an element of danger? Are they liable to develop into cracks? What is the cause, and what is the remedy?"

We trust that some of our readers experienced in the use of concrete will give us information as to the cause of these hair-line veins, and how they may be prevented in the original construction of molded concrete work.

SEWAGE IRRIGATION OF PART OF GOLDEN GATE Park, San Francisco, Cal., is proposed. The outlet sewer in question terminates at present several miles from the Pacific Ocean. For a number of years sewage has been discharged into a depression in the sand just south of the park, but building operations in the vicinity have made necessary a change in plan. The sewage will probably be delivered into a tank and distributed therefrom, all under the direction of the park commission. The plan is a temporary expedient, made necessary by lack of funds to continue the outlet to the ocean. For this information we are indebted to Mr. C. E. Grunsky, M. Am. Soc. C. E., City Engineer of San Francisco.

A COMPETITIVE EXAMINATION for the position of Engineer's Assistant in Charge of Heating, Light and Ventilation will be held in the office of the Building Bureau, Department of Education, New York city, on Wednesday, Feb. 26, at 10 a. m. The position in question will be second to that of Deputy Superintendent of School Buildings, and will carry a salary of $3,250 per annum. Candidates will be examined as to technical knowledge, experience, arithmetic and report, etc., with respective weights of 50, 15, 20 and 15. Under the head of technical knowledge condidates will be examined as to their practical knowledge of the ventilation, lighting and heating of school buildings; of mechanical engineering, including steam and gas engines; of electrical engineering, with particular reference to motors, wiring for lights and installation of bells. Applications must be filed with Geo. McAneny, Secy., and must be in not later than 5 p. m. of Friday, Feb. 21, 1902.

SUCCESSFUL TESTS OF TELEPHONING over telegraph wires were carried out on the Illinois Central Ry. a few days ago. A telephone apparatus was placed in the cab of a locomotive running between Kankakee and Kempton, in northeastern Illinois, and at various points along the road this instrument was connected with the train dispatcher's office at Kankakee by connecting a wire to the telegraph line wire at the side of the roadway. Perfect communication by telephone could be had by this means at all points tried, without the slightest interference with the regular telegraphic service. It is expected that the installation of a telephonic outfit in the cab of every locomotive running over the road will prove of great service as an auxiliary to the regular dispatching, for instance in the case of wrecks, stalled or blocked trains, or other emergencies.

AN ELECTRIC HEADLIGHT which throws a vertical as well as a horizontal beam of light is being tried on the Chicago, Milwaukee & St. Paul Ry. A steam turbine has its shaft connected directly to that of a dynamo, furnishing current for the arc lamps in the headlight. The engine and dynamo run at about 2,000 revolutions per minute, and may be placed directly behind the lantern or in any other convenient position on the engine. A deflector in front of the upper part of the glass projects about 40% of the light in a vertical beam. To prevent the horizontal beam from dazzling the eyes of enginemen on double track, a semi-transparent curtain, on a spring roller, is fitted to the front of the lantern being operated from the cab. When the engine equipped with the electric light is approaching a train on the other track this curtain is unrolled so as to reduce the intense brilliancy of the light. This headlight is the invention of Mr. Edgar L. Edwards, and is being introduced by the Edwards Railroad Electric Light Co., with works at Sixth and Baymiller Sts., Cincinnati, O., and a branch office at 1326 Monadnock Block, Chicago.

EXPERIMENTS WITH MACADAM BINDERS at Providence, R. I., are described as follows in the February Bulletin of the Boston Society of Civil Engineers:

Broad St., between West Friendship St. and Moore St., was selected for the work. It is the longest main thoroughfare in Providence, varying from 66 to 80 ft. in width. The westerly side between the car track and cobble gutter, a strip only 10 ft. wide, was chosen in order to give the pavement a severe test as to binding qualities, the strip being so narrow that the horses follow each other nearly in track. The binders used were composed of the following material: (1) Ironstone (peridotite about 40% iron) and limestone crushed and passed through a ¼-in. screen. The proportions used were nine-tenths iron and one-tenth lime. (2) Bituminous macadam for a tar binder. (3) Diamond Hill quartz crushed to ½-in. in size and dust. (4) Field stone crushed to ½-in. in size and dust. (5) Trap rock crushed to ½-in., in size and dust.

The street was excavated to a depth of about 6 ins., the material being used to repair other streets of the traffic. After this excavation a layer of over 5 ins. thickness remained as a foundation for the new work. The section was made parallel with the finished surface 3 4 ins. below. Then the broken trap was put on in two layers, the first 3 ins. in depth and 2½ to 1½ ins. in size; the second about 2 ins. deep, or sufficient to finish the work to section, and in size 1½ to ½-in. In the case of the ironstone the binder was put on to the ... stone dry, after the roller had passed over it a few times to shape the section, then it was brushed with brooms into the interstices. In the other cases, except the tar the binder was used only when finishing the surface.

The relative merits of the binders, as so far shown by experiment are: (1) Tar or bituminous macadam. (2) Iron and limestone. (3) Trap rock. (4) Field stone. (5) Diamond Hill quartz.

The combination of ironstone (peridotite) and ... while not accomplishing all that was supposed in the matter of oxidizing or rusting, yet it has furnished the best binder we have used except the tar, but owing to its extra cost to quarry and deliver in the city (a distance of 14 miles over hilly road), it is not deemed advisable to use it in place of the trap dust, the latter material of excellent quality being obtained in the suburbs of the city.

The work of testing the binders was performed in July, during the dry season, yet neither binder permeated the surface to loosen or become friable. The tar binder used in this work gave better results than that used in a sample street laid nearly three years ago; although the surface of the latter street has not loosened or broken during this time, yet it did not have the smooth surface of the present work, which to date of writing is similar to the surface of an asphalt pavement, and causes less noise when struck by the horses' hoofs.

The cost of laying the pavements as previously described, exclusive of excavating, is as follows, viz.: Bituminous macadam, 85 cts. per sq. yd.; iron and limestone binder, 51 cts. per sq. yd.; trap rock dust binder, 41 cts. per sq yd. The city crusher was located ⅞ of a mile from the work.

THE U. S. FOREST RESERVES are described in the 21st annual report of the U. S. Geological Survey. Mr. Henry Gannett, Geographer, states that these 37 reserves cover an area of 70,647 sq. miles in the States of Washington, Oregon, California, New Mexico, Wyoming, Utah, Montana, Arizona, Idaho and South Dakota. The report deals with these reserves individually, describing the character of the territory covered, giving estimates of standing timber, etc.

THE HIGH EARTH DAM FORMING DRUID LAKE, BALTIMORE WATER-WORKS.

By Alfred M. Quick, Assoc. M. Am. Soc. C. E.*

Druid Lake, one of the storage reservoirs of the Baltimore Water-Works, is built in a dry ravine in Druid Hill Park, through which ran a stream having a drainage area of not over 100 acres.

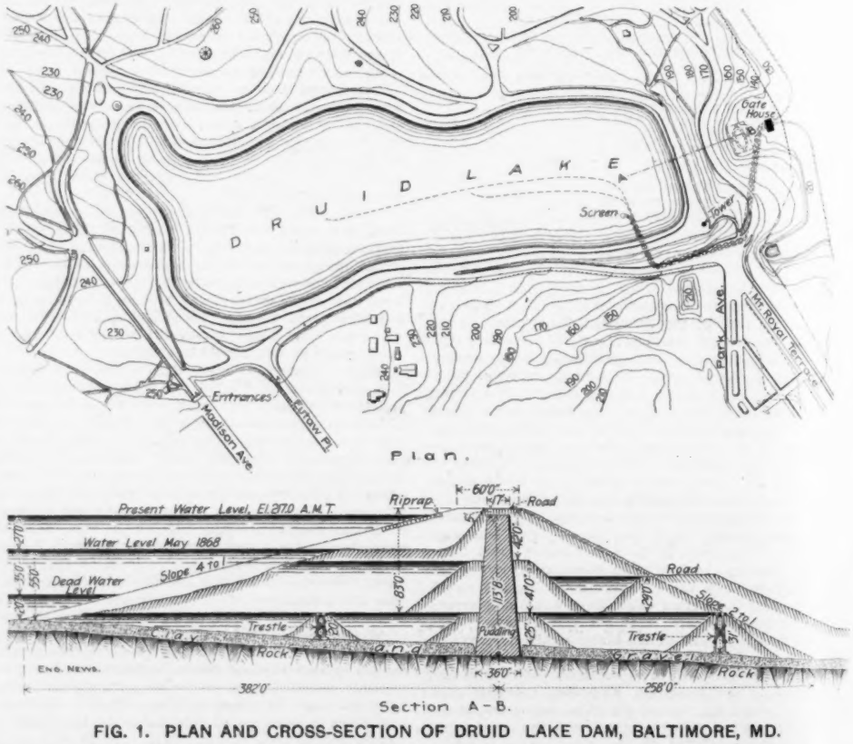


FIG. 1. PLAN AND CROSS-SECTION OF DRUID LAKE DAM, BALTIMORE, MD.

The construction of the lake was begun on March 7, 1864. First, all trees were removed from the area to be covered by the lake. Then the

*Chief Engineer Water-Works, Baltimore, Md.

vegetable top soil was excavated from the surface proposed to be covered by the embankment to a depth of 1 ft., except where sand was found, in which case the excavation was carried down until a material impervious to water was struck. The subsoil was then excavated to the solid rock for the puddle core. In the center of this excavation a groove was cut in the rock 5 ft. wide, extending the full length of the dam. In this groove was built a stone wall, laid in hydraulic cement, 4 ft. wide at the base and 2 ft. wide on top, with battered sides plastered with cement. On and around this wall the puddle core was built to a width of 36 ft. at the base, extending the entire length of the dam. Great care was taken in the method of manipulating the clay for puddle. The banks marked D D, in the section, Fig. 1, on each side of the puddle core were carried up in 6-in. layers with horses and carts and kept about 2 ft. above the puddle, forming a ditch into which water was run from the city mains. The clay was hauled up on these banks and, after removing all objectionable material, it was scattered with shovels in the water, always keeping the water in the ditch a foot or two above the saturated clay. At the same time two lines of trestle work were put up, as shown at E E, extending the entire length of the dam from north to south, to an elevation 83 ft. below the top of the dam. From these trestles material was dumped from cars until the banks marked E E were formed. When these banks had reached the level of those at D D at the puddle core, reservoirs F F were formed into which water was run. Then material was dumped into these reservoirs from cars on tracks laid along the banks D D and E E, the tracks being moved in as the reservoirs F F were filled in. To make the embankment on the outer toe to its required slope, bank G was formed by pulling material down from bank E and ramming it as the bank was carried up. After all this fill was brought up to a level of 83 ft. below the top of the dam, banks B B B were built up in 6-in. layers with horses and carts, thus forming reservoir C on the outside of the embankment, into which material from cars was dumped as before. Reservoir C, inside of the dam, was filled with water from the city mains, and into this water material was dumped from cars, carrying the embankment out to the required slope. The banks A A were constructed entirely by horses and carts, in 6-in. layers up to the required height, and over each layer a heavy roller was run as the work progressed. The water on the inside was drawn down 20 times or more while the work progressed and the earth was so firm and compact that inside of 24 hours after drawing down the water a heavy two-horse roller was run over the inside slope to roll it. The material in both the puddle wall and the embankment consolidated well, and there was no indication of slipping from the action of water against either, and no evidence of cracks in the completed work.

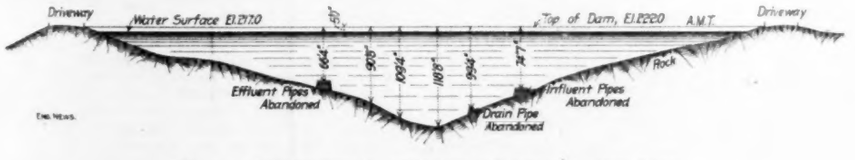


FIG. 2. LONGITUDINAL SECTION OF DRUID LAKE DAM.

In facing off the inside slope of the dam, material was removed by excavating machines from the sides of the lake and was brought down to the dam in cars and dumped, then loaded up in carts and distributed in 3-in. layers on the slope. The humps and knobs of earth lying immediately adjacent to the dam were also removed by horses and carts and distributed in like manner in 3-in. layers. These layers were not only firmly packed by horses and carts constantly traveling over them, but three heavy four-horse rollers were kept going night and day over each layer as it was put on. In this manner the slope was carried up to the required line; after which 2 ft. of good puddle was placed over the entire surface thus completed and the whole covered with 1 ft. of gravel, all being carted on and rolled down in layers as before.

After the completion of the embankment the inside slope was riprapped from about 2 ft. above high water line to about 10 ft. below that line with large stones quarried principally from the bed of the lake. The top 6 ft. of this riprapping was then covered with small gravel stones, free from dirt and from 1 to 3 ins. in diameter. Above the riprapping the inside slope was sodded, as was also the entire outer slope.

The dimensions of the dam, as completed, are as follows: Puddle core, 36 ft. wide at bottom, 17 ft. wide at top. Extreme height of dam, 119 ft. Embankment, 640 ft. extreme width at base, 90 ft. wide at high water mark, 60 ft. wide at top; inner slope 4 to 1, outer slope 2 to 1. The extreme height from the lowest point on the outer toe is 100.33 ft. The greatest depth of water in the lake is 82 ft. The capacity of the lake is 429,000,000 gallons.

Some time after the lake was completed a driveway was built along the outside slope of the dam and about half way up, as shown on the accompanying plan, Fig. 1, and in the view, Fig. 3. The embankment formed in constructing this driveway serves to still further strengthen the dam, but was not built for that purpose, but to connect two entrances to Druid Hill Park.

The interior portion of Druid Lake was completed in December, 1870, and on Jan. 2, 1871, water was first let into the lake for the purpose of filling it for permanent use as a storage reservoir.

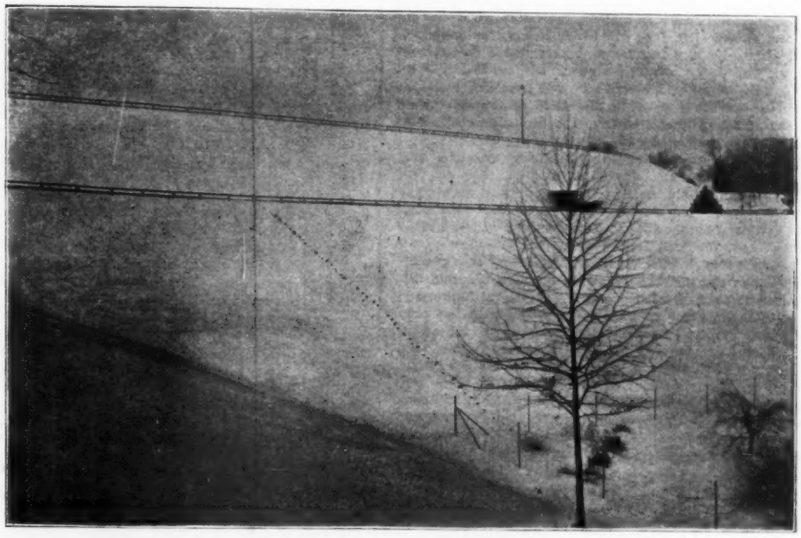


FIG. 3. VIEW OF DRUID LAKE DAM FROM BELOW.

It may be of interest to note that the influent, effluent, and drain pipes were originally constructed through the dam at the east end of the lake, as shown on the accompanying longitudinal section of the dam, Fig. 2. In the spring of 1866, about twelve months after the drain pipe was laid, it was found to be badly fractured. In the fall of the same year the three influent pipes were also found to be badly cracked. These pipes were laid upon solid earth in trenches dug to a uniform grade and were then covered with the embankment, and where they passed through the puddle wall they were supported on stone piers 6 ft. apart laid in hydraulic cement. These stone piers were carried up and around the pipes so as to form collars as an additional security against any leakage along the pipes. Upon the discovery that these pipes were cracked, the water in the lake was at once drained out through these fractured pipes, the embankment was excavated on each side of the puddle core as far as was practicable, and the pipes thus exposed were removed. The sections of each pipe left extending through the puddle core and for a short distance each side thereof under the high part of the embankment were plugged on the ends with cast-iron caps leaded on, and the excavation made into the embankment was refilled with good puddle. The three effluent pipes, which were built through a shallower section of the dam than the influent and drain pipes, were not injured, but were afterwards closed off on the inside of the lake and new influent, effluent, and drain pipes were run into the lake at a point on the south side of the lake where the embankment over the original surface was much lower than that of the main dam at the east end, as shown on the accompanying plan.

In 1868, there being considerable apprehension as to the safety of the dam and lake as up to that time constructed, the water board requested three well-known engineers, Messrs. Isaac R. Trimble, Chas. P. Manning and J. H. Tegmeyer, to investigate and report on the work.

After a very thorough and careful investigation these engineers reported in substance that the puddle wall and embankment were of the best quality; were constructed according to the most approved practice, and that it would be difficult to make a more perfect bank than that of Druid Lake. With regard to the breaking of the pipes in the embankment their conclusion was that the damage was due to the error of laying part of their length in the embankment and part on piers, thus subjecting them to unequal pressure from the bank above and unequal resistance from the foundations below.

Since the dam was built, so far as is known, there has never been any evidences of a leak through the embankment, and no repairs have ever been made upon it.

The dam was designed by and constructed under the supervision of Robert K. Martin, at that time the Civil Engineer of the Water Board and subsequently for many years Water Engineer.

TESTS OF LOCOMOTIVE BRAKE SHOES.*

By W. H. Stocks.†

Last summer a certain type of brake shoe was offered to the motive power department of the Chicago, Rock Island & Pacific Ry., with the claim that it was a much better shoe than that which they had adopted as standard for locomotive driving wheels.

The claims made were as follows: (1) Greater durability; (2) equal, if not superior, retarding power; (3) superior tire dressing effect. In proof of these claims,

*Abstract of a paper read at the February meeting of the Western Railway Club.

†Master Mechanic; Chicago, Rock Island & Pacific Ry. Chicago, Ill.

records were presented showing the satisfactory results obtained on other roads.

In July a service test was arranged and certain engines were equipped with the different brake shoes. Brake shoe "A" represented a cast-iron shoe having two curved inserts of very hard white iron, disposed along the outer tread bearing portion of the shoe, and three similar inserts disposed along that portion of the shoe covering the wheel flange, the center portion of the shoe over the limits of the rail wear being cut away. The inserts presented well defined cutting edges transverse to the wheel tread. The back of the shoe was reinforced with a steel plate to prevent fracture. This plate, however, has nothing to do with the face of the shoe. Brake shoe "B" represented a cast-iron brake shoe having four crucible cast-steel inserts arranged along the outer tread bearing portion of the shoe face and three inserts of crucible cast steel disposed along the flange groove, these inserts presenting well defined cutting edges transverse to the wheel face. The shoe surface was recessed over the limits of rail wear on the tire, while the ends of the shoe were tapered and heavily chilled from the back, the chill being confined to the beveled ends.

Each engine was equipped on one side with the "A" shoe and on the other side with the "B" shoe, so that as nearly as possible the two classes of shoes were given equal service under similar conditions. The road tests with five engines showed an average wear of 3½ lbs. of the "A" shoe for each 1 lb. wear of the "B" shoe.

So convincing were the figures showing the greater durability of the "B" shoe, that the question was naturally raised as to its frictional effect, the general impression being that the more durable "B" shoes would not stop the engine in as short a distance as the "A" shoes on account of being more than three times as hard. This point was taken up and discussed with the makers of the "B" shoes, who were convinced, however, that their shoe possessed good holding power, which seemed to be confirmed in part by superior dressing effect on the tire, and that this work of wearing down the wheel tread meant that the shoe was surviving at the expense of the wheel, whereas the "A" shoe probably did the work at its own expense.

A series of road tests was suggested for the purpose of demonstrating beyond any doubt the difference between the two types of shoes in question as regards stopping a locomotive, and Mr. Geo. F. Wilson, Superintendent of Motive Power and Equipment, C., R. I. & P. Ry., gave instructions to make these tests. In order to get the best possible data, the dynamometer car of the C., M. & St. P. Ry. was secured through the courtesy of Mr. A. E. Manchester, Superintendent of Motive Power of that road, accompanied by their expert, Mr. Goodwin.

On December 2, 1901, the tests were started on our main line southwest of Blue Island, Ill., to compare the retarding power of a set of the "A" driving brake shoes, a set of the "B" driving brake shoes, and a third set of shoes which we will designate as "C," which were similar in shape to the "B" shoes, but differed in having the chill omitted from the ends, and an additional insert in both the tread and flange bearing portion. This extra set was introduced for the purpose of determining what effect would result from the omission of the hardened ends and an increase in the cutting effect due to an additional insert.

The first tests consisted of stopping an engine and dynamometer car, using the emergency application of the driver and tender brakes (the latter being used without change through all the tests), while the engine was drifting with steam shut off at as nearly as possible the desired speed. Two stops with each set of driving shoes were made with the engine and dynamometer car at 40 miles per hour, and two stops at 65 miles per hour, the endeavor being to always make the stops as nearly as possible on the same stretch of track.

Following these tests, a train consisting of two baggage cars and four passenger coaches equipped with steel tired wheels (using unflanged coach brake shoes unchanged throughout all the tests) were attached to the engine and dynamometer car. Two stops were then made with each set of driving shoes at a speed of 40 miles per hour, and two stops at a speed of 60 miles per hour with the full train.

The engine used in this test was No. 858, weighing 65 tons, exclusive of tender; cylinders, 19 × 26 ins.; six drivers, 63¾ ins. outside diameter; four-wheel truck; steam pressure, 180 lbs. The first day, Dec. 2, the weather was clear, with a good dry rail. The second day, Dec. 3, in the morning, during the tests with the "C" shoes, the rail was quite frosty and slippery, so that there was considerable trouble in gaining speed. The third day, Dec. 4, was clear, and the rail dry and clean.

The rate of grade naturally has some effect on the results of the test in lessening or increasing the lengths of the stops accordingly as the grade was up or down. The records do not indicate a close enough agreement in the distances run under the various rates of grade to figure definitely the proper correction in order to reduce the stops to a level grade basis. Below is indicated the average grade of the two runs of each set of shoes at the same speed. The only correction applied was that necessary to bring the stops to the same speed for comparison—that is, 40, 60 and 65 miles per hour.

The results of these tests are given in the accompanying tables, in which the stops are arranged in pairs for the purpose of ready comparison, each couple representing as nearly as possible stops on the same grade. Where the grades are different, it is so noted; they are all down grades. The last column shows the comparison between each pair of stops on the basis of the distance run equated to a common speed.

Table No. 1 shows the "A" shoe to be superior to the "B" shoe as to retardation to the extent of 5.7% at the speed of 40 miles per hour, while the "B" shoe is 4% ahead of the "A" shoe at the speed of 65 miles per hour in so far as stopping the engine alone is concerned.

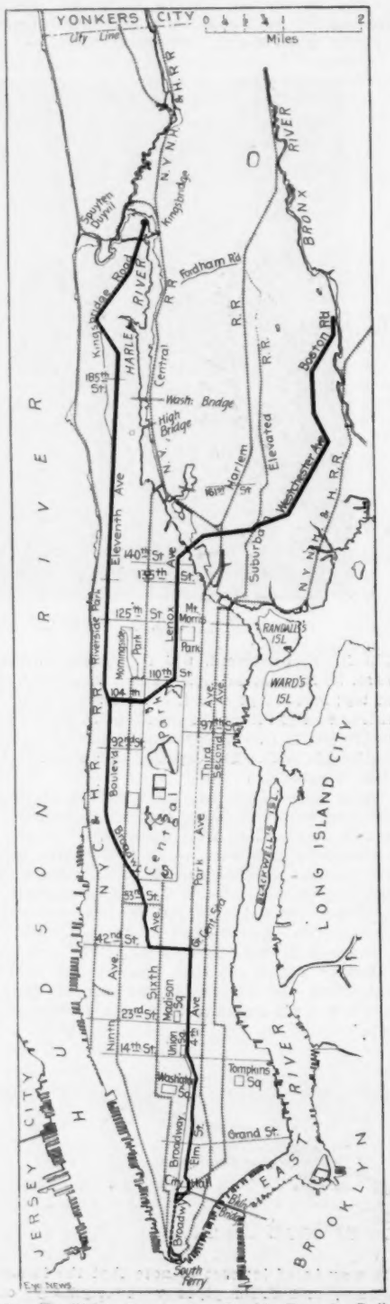


Fig. 3. Final Route for Rapid Transit Railway Adopted by the Rapid Transit Railroad Commission of 1894.

TABLE NO. 1.—Engine and Dynamometer Car.

	40 miles per hour: Length of stop, ft.	40 miles per hour: Av. grade, ft. per mile.	40 miles per hour: Per cent.	65 miles per hour: Length of stop, ft.	65 miles per hour: Av. grade, ft. per mile.	65 miles per hour: Per cent.
1 A.	1,443	7½	100.0	4,363	11½	96.0
1 B.	1,530	Level.	94.3	4,188	17½	100.0
2 A.	1,443	7½	100.0	4,363	11½	94.7
2 C.	1,660	7½	87.0	4,135	12½	100.0

The "A" shoes made, at 40 miles per hour, a 13% shorter stop than the "C" shoe, while at 65 miles per hour the "C" shoe stops 5.3% shorter than the "A" shoe. At 40 miles per hour, the shortest stop was made in 1,321 ft. with the "A" shoes. At 65 miles per hour, the shortest stop was made with the "B" shoes in 4,188 ft.

Table No. 2 shows that at a speed of 40 miles per hour the "B" shoes stop the train in 1.2% shorter distance than the "A" shoes, while at 60 miles per hour the "A" and the "B" shoes stop the train in exactly the same distance. With "A" on dry rail, "C" on wet rail, the "A" shoes at 40 miles per hour stop the train in 8% less distance than the "C" shoes, while at 60 miles an hour the "A" shoes stop the train 14.4% shorter distance than the "C" shoes.

The shortest stop made with train at 40 miles per hour was made in 924 ft. by the "B" shoes. At 60 miles per hour the shortest stop was made by the "A" shoes in 2,210 ft. There were no brakes used on the dynamometer car in any of the stops. Averaging the stops with the "A" and "B" shoes, we find that the shoes were practically of equal efficiency in stopping the engine. From the figures of this report we can now reach some definite conclusion as to the comparative merits of the shoes:

(1) From a frictional standpoint, which is the greatest virtue in the brake shoe, there appears no choice.

(2) From the standpoint of durability, the "B" shoe, as shown in the service test, has 3½ times the life of the "A" shoe. It is about 12½% heavier, which will reduce the advantage slightly, but at the same price per pound must be far more economical.

(3) As to the action on the tire, there are no records of measurements made to determine the exact effect, but all who have observed the action of the shoes in question agree that the "B" shoes do the best work.

It is regretted that no tire diagrams have been taken to show exactly the cutting effect of each shoe, as it is of considerable importance that the brake shoe should cut the wheel as much as possible outside the limits of the rail wear, and the brake shoe which has a continuous and uniform cutting action on the wheel tread can save its cost over a non-tire dressing shoe by the greater length of time the engine is kept out of the shop for tire turning, provided, of course, the brake shoe is recessed above the limits of rail wear, and this is the case in the shoes which have been tested on our road.

Tire dressing is an important factor in the driving brake shoe, because by reason of this cutting action upon the tire, friction is generated from the use of a hard and durable shoe which could not possibly be obtained from a shoe whose hardness was contained in a simple rubbing face which would not hold up a cutting edge.

TABLE NO. 2.—Engine and Dynamometer Car and Six-Car Train.

	40 miles per hour: Length of stop, ft.	40 miles per hour: Av. grade, ft. per mile	40 miles per hour: Per cent.	60 miles per hour: Length of stop, ft.	60 miles per hour: Av. grade, ft. per mile.	60 miles per hour: Per cent.
3 A.	954	11¾	98.8	2,323	16½	100.0
3 B.	943	-7	100.0	2,323	12½	100.0
4 A.	954	11¾	100.0	2,323	16½	100.0
4 C.	1,177	3½	81.0	2,714	37½	85.6

A REPORT ON THE CONDITION OF STREET BRIDGES IN INDIANAPOLIS.

An old and overloaded highway bridge over the White River at West Washington St., Indianapolis, Ind., collapsed Jan. 16, after it had been declared unsafe by the City Engineer, Mr. J. B. Nelson, but had been repaired by order of the Board of Public Works. As a result of this accident, the Board engaged Mr. T. L. Condron, M. Am. Soc. C. E., of Chicago, to inspect and report on the other four bridges over the river, all of which are old structures and three of which now carry electric railway cars, although never designed for such loading. Mr. Condron's report, which we print below, shows very conclusively the dangerous condition of the bridges:

The writer has made a complete examination of the four bridges across the White River within the city limits of Indianapolis, commonly known as: (1) the West Michigan St. bridge; (2) the River Ave. bridge; (3) the Morris St. bridge; and (4) the Emmerichsville bridge, and he respectfully submits herewith, complete reports upon the strength and safety of these structures.

The estimated weight of the electric cars used in computing the stresses, was furnished by the engineer of the Indianapolis Street Ry. Co., who stated that his company was running over these bridges at this time, cars 33 ft. long and weighing 9 tons or 18,000 lbs., exclusive of passengers, and capable of carrying 100 passengers, thus increasing the weight by 15,000 lbs., making the total weight of fully loaded cars 33,000 lbs. each. These cars are carried on two axles, 7 ft. 6 ins. apart, thus making the load on each axle 16,500 lbs. The weight of the large double-truck, eight-wheel cars in use by the street railway com-

pany, is very much greater than the above, and obviously none of these larger cars should be allowed to run over the bridges here reported upon.

The uniform moving load used in these computations of 80 lbs. per sq. ft. of roadway, is equivalent to the weight of a crowd of pedestrians over the entire roadway or to the weight of moderately heavy traffic teams. The following table gives the loading and unit stresses now generally specified for the designing of city and country bridges, from which it will be seen that the loads adopted by the writer are none too great, while he has allowed as large maximum unit stresses as can safely be considered, especially in view of poorly designed details of connections.

Comparison of Usual Specifications for Live Loads and Unit Stresses, with those Adopted for this Report.

Specifications for steel bridges.	Concentrated loads on 2 axles, lbs.	Uniform live loads per sq. ft., lbs.	Unit stresses per sq. in., lbs.
For city traffic.*	48,000	140	15,000
Suburban traffic.*	24,000	140	15,000
Country roads.†	24,000	100	15,000
For investigation of iron bridges used for this report.‡	33,000	80	§16,000
Specifications for steel bridges for country roads.‡	12,000	75	15,000
For investigation of iron bridges used for this report‡	6,000	80	§16,000

*Heavy electric cars.
†Light electric cars.
‡Indianapolis electric cars.
§Since steel is at least 20% stronger than iron, this unit stress is comparable with 19,200 lbs. per sq. in. for steel.
‡Without electric cars.

The writer makes the following recommendations, based upon the facts presented in the attached reports:

First: That the West Michigan St., River Ave., and Morris St. bridges be closed to street car traffic, as the chances of having heavily loaded cars on these bridges combined with ordinary traffic loads, could not be positively guarded against by any system of watchmen, and such a combination of loads would actually endanger the lives of a large number of people.

Second: That the roadways of the West Michigan St. and Morris Ave. bridges be restricted to a clear width of 10 ft. each, confining the traffic on either roadway of both bridges to the 10-ft. adjacent to the outside trusses, and keeping all loads off of those parts of the present roadways nearest to the center trusses. In the case of the Morris Ave. bridge, also removing the sidewalks. This will reduce the possible loads on the bridges with minimum interference to traffic, and cause the trusses to be uniformly loaded with respect to their relative strengths.

Third: That the River Ave. bridge be left open to ordinary street traffic, while closed to street cars, and that street railway rails like those now in the floor, be kept on the bridge and connected to the floor beams. Such rails will, by their stiffness, distribute concentrated loads over several beams, thereby materially reducing the floor beam stresses. The floor beams can also be somewhat strengthened by new truss rods properly connected. Expensive repairs are not recommended, however.

Fourth: That the floor beams of the Emmerichville bridge be strengthened at once by trussing, and that the bridge be used as at present, for ordinary highway traffic only; no electric cars ever being permitted upon it. While the structure is considerably over stressed by the loading assumed, the location is such that at present heavy traffic does not frequently pass over the bridge in both directions at the same time.

Fifth: That each one of these bridges be replaced with the least possible delay by well-designed and adequately strong modern structures that can be safely depended upon to carry the heavy street traffic of a large city, including electric railway cars of the largest type now used, or that can be reasonably anticipated.

In conclusion, the writer advises against the expenditure of money in attempts to strengthen any of these bridges, except such as are suggested above for the floor beams of the River Ave. and Emmerichville bridges.

Respectfully, T. L. Condron,
Chicago, Feb. 11, 1902. Consulting Engineer.

ADDENDA.

In view of the fact that the stresses given in these attached reports as resulting from loads including electric cars, are based upon two fully loaded cars weighing together 66,000 lbs., being on one span at the same time; and since one unloaded car weighs approximately 18,000 lbs., it is the writer's opinion that it will be reasonably safe as a temporary measure (until the spans can be supported by trestles, as has been proposed by President McGowan, of the street railway company), to permit the street railway company to run cars, without passengers, said cars weighing approximately 18,000 lbs., over these bridges under the following restrictions:

1.—For West Michigan St. and River Ave. bridges. Only one 18,000-lb. car, and that without passengers, to be permitted on the bridge at any one time, and then only, provided that no teams nor pedestrians shall be on the same span during the passing of the car.

2.—For West Michigan St. and Morris St. bridges. If the street railway tracks be so changed on either or both bridges that the track centers shall be approximately 5½ ft. from the center line of the outside trusses, and the two roadways restricted to widths of 10 ft. each adjacent to the outside trusses, and the sidewalks on Morris St. bridge be removed, then one car at a time (without passengers), said car weighing approximately 18,000 lbs., may be run over either or both of these bridges so changed, irrespective of other traffic.

Morris Street Bridge.—In the writer's opinion, it is not safe to leave this bridge open for any kind of traffic, except with the restricted roadways, and with the sidewalks removed, as stated above, and also provided for in the special report on this bridge. Respectfully,

T. L. Condron,
Indianapolis, Feb. 13, 1902. Consulting Engineer.

In explanation of the supplementary report above printed, it should be said that as the cars are single-ended and cannot be reversed and the car sheds are all on one side of the river, it became almost essential for the accommodation of the public that cars should be moved across the river to some extent. To meet these conditions Mr. Condron laid down the precautions noted in his second report. Policemen are stationed at each bridge to see that no more than one loaded wagon or one empty street car passes onto the bridge at one time. Passengers alight at one end of the bridge and wait till the car has passed over before walking across. The City Engineer has been directed to have plans prepared at once for the timber trestles. It seems probable that these trestles will have to do duty for a considerable time, the city being unable to provide the necessary funds for the construction of five new bridges at the present time. As noted in our construction columns last week, the City Engineer is preparing plans for three alternative designs for the Washington St. bridge; these designs are for steel plate girder, masonry arches and concrete arches, with five spans in each case.

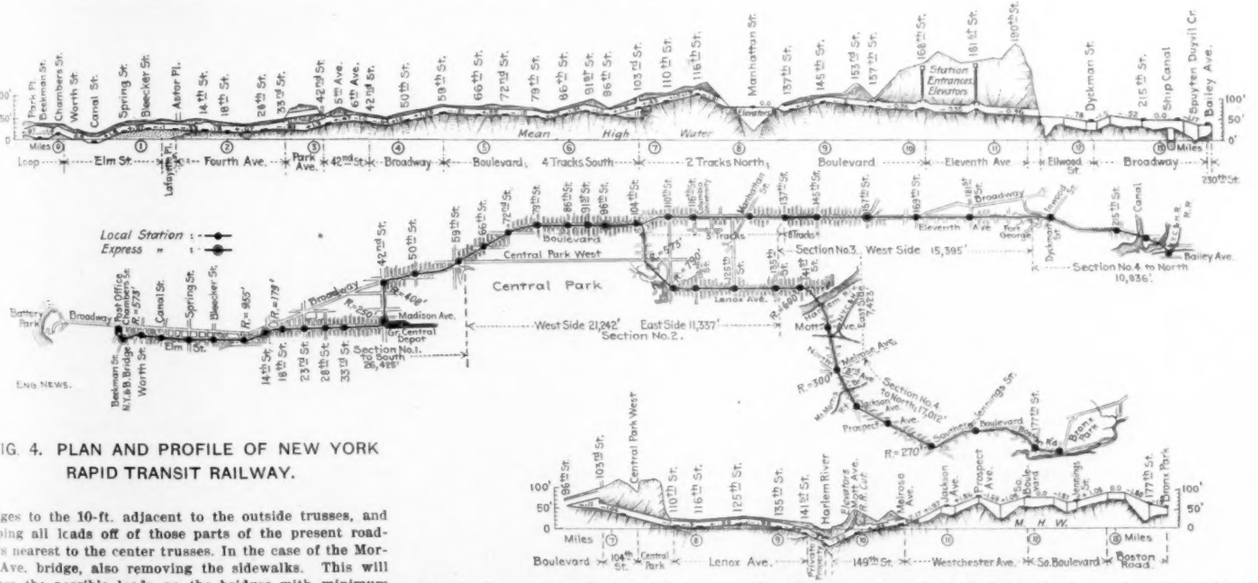


FIG. 4. PLAN AND PROFILE OF NEW YORK RAPID TRANSIT RAILWAY.

THE NEW YORK RAPID TRANSIT RAILWAY.

IV.

General Description of the Work.

The bid of Mr. John B. McDonald to construct the New York Rapid Transit Railway was made on general plans and specifications submitted by the Rapid Transit Railway Commission, and prepared by its Chief Engineer, Mr. William Barclay Parsons, M. Am. Soc. C. E. It was stipulated in the contract, however, that these plans and specifications would be amplified and altered wherever such changes were deemed necessary by the engineers of the commission. Advantage has been taken of this stipulation by the commission, and many of the minor details and some of the general features of the original contract plans have been materially altered. In succeeding articles these final plans will be presented in some detail; here it is proposed to give in outline a description of the work to be done, and of the organization, which has been developed to carry it out.

ROUTE OF LINE.—As stated in the preceding article and shown there by Fig. 2, the route adopted by the commission in 1896 substituted Elm St. and Fourth Ave. for Broadway, and, at 42d St., divided the main line into two branches, forming an east side and a west side line, separated by Central Park. The route on which it was ultimately decided to construct the line differed from this first route in the location of the east side line. Instead of making the division of the two lines at 42d St., it was made at 104th St.; the line along the east side of Central Park was abandoned entirely, and that portion of the same branch which lay north of the Harlem River was changed from the direct course along Gerard and Jerome avenues, and swung sharply east along Westchester Ave. and Boston Road. Fig. 3 shows the new route.

As planned for actual construction, therefore the line starts from the Postoffice and City Hall Park, as shown by Fig. 4. The two middle tracks, or the tracks for express trains, start from a dead end on Park row near Broadway and continue side by side up Park Row to Center and Elm Sts. Ultimately, this dead end will be removed and the two center tracks will be continued down Broadway to form the extension to Brooklyn. The left-hand outside track, looking south, will curve to the right, pass under the middle tracks, make a loop in City Hall Park and come back to the right-hand outside track. Proceeding from the loop the two outside tracks and the two inside tracks run parallel and side by side, forming a four-track line which passes under Center and Elm Sts., and a few blocks of private property and reaches Fourth Ave., at about Ninth St. From this point, Fourth Ave. and Park Ave. are the routes pursued until 42d St. is reached, when the line turns west along 42d St., which it follows to Broadway. Broadway is then followed until 97th St. is reached, when the four-track line is separated

into two double-track lines, as will be described further on. The four-track line, between the City Hall Park and 97th St., will be known as the main line. In this portion the two inside tracks will be used by express trains, stopping only at comparatively long distances, and the outside tracks will be used by local trains, stopping at stations about ¼-mile apart.

At about 96th St., on the main line, suitable crossovers will be provided, so as to permit trains to pass at will between the northbound local and express tracks, and also between the southbound local and express tracks. At a suitable point north of these crossovers the outside tracks will rise so as to permit the inside tracks, on reaching 103d St., to curve to the right and pass under the right-hand outside track. The inside and outside tracks then take separate routes north as double-track lines, except at the points noted hereafter. The inside tracks which turn to the right at 102d St., continue east and north to Bronx Park, passing under a portion of Central Park and under the Harlem River in the route. This branch will be known as the East Side Line. The outside tracks turn slightly to the left from the point of separation, and then continue along a route generally parallel to the North River, through Spuyten Duyvil to about 230th st. This branch will be known as the West Side Line. It has two tracks except between 104th and 145th streets, where there are three tracks, and between 137th and 145th streets, where there are eight tracks, five of which are to be used for storage purposes. At one point between 123d and 135th Sts. the West Side Line will rise to the surface and pass over a depression, on elevated structure or viaduct, and for a considerable distance both this and the East Side Line will be pure elevated railway construction. This elevated construction and viaduct; the tunnels under the Harlem River, under Central Park and under the Fourth Ave. tunnel, and the Post-Office loop and 96th St. crossovers call for special modifications of construction. Except at these points the construction will conform closely to a single standard construction adapted to four-track, three-track and two-track lines.

PROFILE OF LINE.—The profiles of the main line and its two branches are shown by Fig. 4. As will be observed, the main line, from the City Hall Park to 104th St., will be entirely subway and tunnel work, and will have a generally ascending grade never greater than 1.81%. From 104th St. the three-track West Side Line follows an ascending grade to 116th St., and then a descending grade to its terminus. At the crossing of Manhattan St., the road will come to the surface and traverse the gorge on a viaduct; it will then plunge beneath the surface and continue underground to a point just north of 190th St., whence it continues as elevated railway to its terminus. The maximum grades on the West Side Line are 2%. The East Side Line leaves 104th St. in tunnel and continues underground to a point north of the Harlem River, with a generally descending grade nowhere greater than 1.04%, except where the road passes under the Harlem River and rises on the opposite bank with grades of 3%. At Melrose Ave., north of the river, the line comes to the surface and continues as elevated railway on a generally ascending grade to its terminus. Only the general features of the profile have been described; the details are more clearly shown by the drawings of Fig. 4.

STANDARD SUBWAY CONSTRUCTION.—For all portions of the line except the deep tunnels at Fourth Ave., Central Park and the Harlem River, the underground construction will conform to a general standard adapted to four-track, three-track and two-track lines. This standard section is rectangular, with the tracks side by side except at certain terminal and crossing points, and consists of transverse bents of steel columns and roof beams, which carry side walls and a roof of concrete, and rest on a concrete floor. The interior columns of the bents are built-up columns, but the side columns are I-beams. The roof beams are rolled I-beams. The entire four sides of the section are protected from seepage by a layer of water-proofing embedded in the floor, walls and roof. Fig. 5 shows the general details of the standard subway adapted to four-track line.

SPECIAL TUNNEL CONSTRUCTION.—At three places on the route the standard subway construction is changed to a special tunnel construction. Proceeding north the first of these special tunnels is designed to carry the road underneath the present Park Ave. tunnel for surface street railways which extend under Park Ave., from 33d St. to 42d St. This portion of the road will consist of two parallel double-track tunnels in rock. Fig. 6 shows the sectional profile and dimensions of these tunnels and their position in relation to the existing street railway tunnel. The second of the special tunnels is designed to carry the double-track East Side Line under the high ridge between 103d St. and 110th St., at the north end of Central Park. The Central Park tunnel will be a double track, masonry lined tunnel through rock and earth. Fig. 7 shows the sectional profile and dimensions adopted for both earth and rock. The third and last of the special tunnel sections carries the East Side Line under the Harlem River. This tunnel will consist of two parallel, circular, cast-iron-lined tubes between the bulkhead lines, and north and south approaches to these tubes consisting of double-track masonry-lined tunnels. Fig. 8 is a longitudinal profile of the tunnel, Fig. 9 is a section of the double-track approach tunnels, and Fig. 10 is a section of the parallel channel tunnels.

VIADUCT AND ELEVATED LINE CONSTRUCTION.—The above-ground portions of the rapid transit railway, with the exception of a few short stretches, are either viaduct or elevated railway construction. The viaduct line consists of that portion of the West Side Line which crosses the Manhattan valley. Here the tracks will be carried on a steel structure consisting of an arch flanked on each end by a framed tower and plate girder viaduct of the familiar American type. The elevated lines constitute the northern portions of both the East Side and the West Side lines. They consist of plate girder spans supported on plate cross girders carried by columns.

STATIONS.—The stations for the Rapid Transit railway are of two classes, namely, local stations and express stations. On the four-track main line, from City Hall to 104th St., there will be 22 stations, of which five are express stations. The locations of these 22 stations are shown by the map, Fig. 4. The length of the four-track line is 6½ miles, and it is anticipated that express trains will run this distance in 17 minutes, including all stops. The underground station construction will consist simply of a local lateral enlargement of the standard subway, with the addition of the necessary platforms, stairways, elevators, and station equipment and fittings. On the two branches the stations are all designed to serve both as local stations and as express stations. The locations of the branch line stations are shown by the map, Fig. 4. On the elevated portions of the branch lines the stations will, of course, be elevated structures resembling in their general characteristics the familiar elevated railway stations of New York, Boston and Chicago.

COLLATERAL CONSTRUCTIONS.—In addition to the construction of the railway itself, it is necessary to construct or reconstruct certain sewers, and to adjust, readjust and maintain street railway lines, water pipes, subways and other surface and subsurface structures, and to relay street pavement. The specifications provide fully for the methods by which this work shall be done.

POWER PLANT.—The power house for the Rapid Transit Railway is planned to contain twelve engines, each rated at 7,500 HP. at their most economic loading. Each engine consists of two compound engines, operating on one shaft, with a 5,000-K-W. generator between them. Eight of these engines have been contracted for, and will be built by the Allis-Chalmers Co. Further details of the power plant are best postponed until a later time, when the plans are more definitely developed.

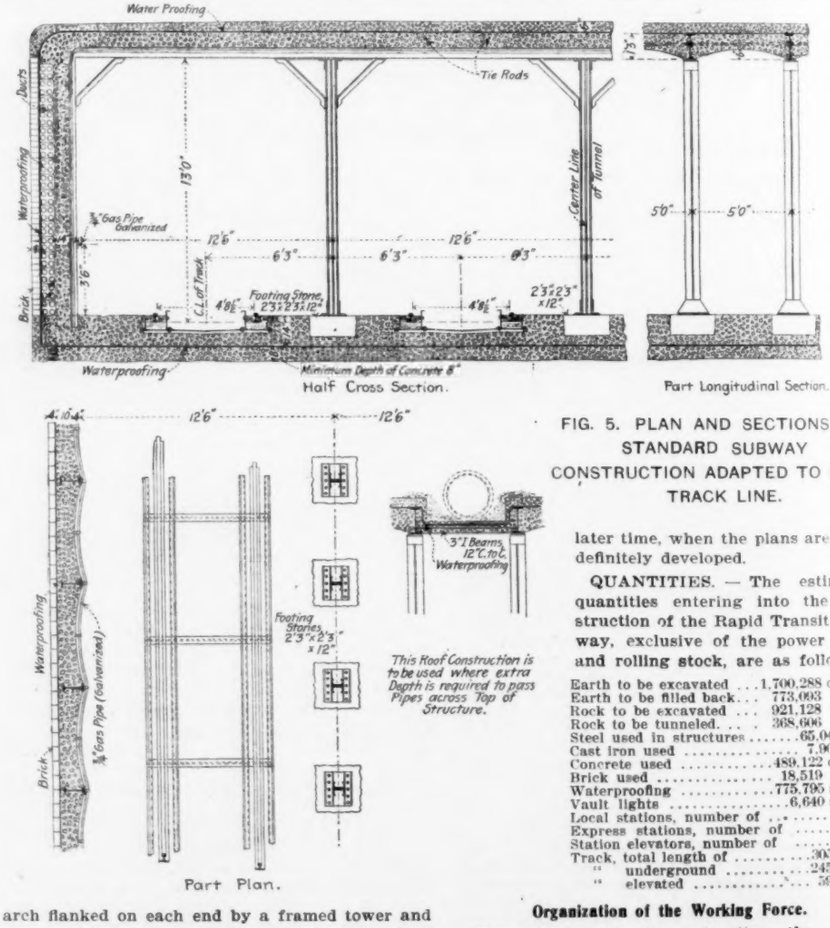


FIG. 5. PLAN AND SECTIONS OF STANDARD SUBWAY CONSTRUCTION ADAPTED TO FOUR TRACK LINE.

QUANTITIES. — The estimated quantities entering into the construction of the Rapid Transit Railway, exclusive of the power plant and rolling stock, are as follows:

Earth to be excavated	1,700,288 cu. yds.
Earth to be filled back	773,093 " "
Rock to be excavated	921,128 " "
Rock to be tunneled	368,606 " "
Steel used in structures	65,044 tons
Cast iron used	7,901 "
Concrete used	489,122 cu. yds.
Brick used	18,519 " "
Waterproofing	775,795 sq. yds.
Vault lights	6,640 sq. yds.
Local stations, number of	42
Express stations, number of	5
Station elevators, number of	10
Track, total length of	305,380 ft.
" underground	245,514 "
" elevated	59,766 "

Organization of the Working Force.

The actual work of constructing the Rapid Transit Railway is being carried on by the general contractor, Mr. John B. McDonald, under the supervision and according to the plans and specifications of the Board of Rapid Transit Railroad Commissioners. Two organizations exist, therefore, for carrying on the work, viz.: that of the Rapid

Transit Commission and that of the contractor. These two organizations are separate and distinct; one is a public body established and maintained by a legislative act, and receiving its working funds from the public treasury; the other is a private body established and maintained by private individuals and looking to them for its working funds.

COMMISSION'S ORGANIZATION.—The controlling body in charge of the construction of the Rapid Transit Railway is the "Board of Rapid Transit Railroad Commissioners of New York," holding its authority by legislative acts. These commissioners are Messrs. Alexander E. Orr, Mortis K. Jesup, H. B. Claflin, John H. Starin, Woodbury E. Langdon, Charles Stewart Smith, and the Mayor and the Comptroller of New York city, *ex officio*. The direct work of construction is carried on by this commission through its engineering staff, which is composed of the following heads of departments: Chief Engineer, Mr. Wm. Barclay Parsons, M. Am. Soc. C. E.; Deputy Chief Engineer, Mr. George S. Rice, M. Am. Soc. C. E.; Sewer Division, Mr. Calvin W. Hendrick, M. Am. Soc. C. E.; First Division, Mr. Albert Carr, M. Am. Soc. C. E.; Second Division, Mr. Alfred Craven, M. Am. Soc. C. E.; Third Division, Mr. Beverly R. Value, M. Am. Soc. C. E.; Fourth Division, Mr. Eugene Klapp, M. Am. Soc. C. E.; General Inspector of Designs; Mr. St. John Clarke, General Inspector of Materials, Mr. Wm. A. Aiken, M. Am. Soc. C. E. Working under these officers and heads of divisions are about 200 engineers and assistants. Each Division Engineer named has direct charge of the work on certain portions of the line known as the first, second, third and fourth divisions, except that the work of the Sewer Division comprehends the entire line so far as sewer diversion is concerned. The First Division comprises the main line from the City Hall terminus to 41st St.; the Second Division comprises the main line from 41st St. to 104th St.; the Third Division comprises the subway and tunnel work on the East Side and West Side lines, and the Fourth Division comprises all the elevated structure and viaduct. Each division is divided into a number of sections, viz., four for the First Division, four for the Second Division, six for the Third Division and three for the Fourth Division, and each section is in charge of an Assistant Engineer.

CONTRACTOR'S ORGANIZATION.—The general contractor for constructing and operating the Rapid Transit Railway is Mr. John B. McDonald, who is backed by the banking house of August Belmont & Co., of New York, which has organized the Rapid Transit Subway Construction Co., to finance the construction of the road under Mr. McDonald's contract. It is also currently understood that this company will operate the road when it is completed. The contractor's engineering staff comprises as heads, Mr. S. L. F. Deyo, Chief Engineer, in charge of the line construction; Mr. John Van Vleck, Mechanical Engineer, and Mr. L. B. Stillwell, Consulting Electrical Engineer. Mr. E. P. Bryan will have charge of the work of equipping the road for operation. None of the actual work of construction is being done by the general contractor; the work has been divided into 17 sections, and for each section a subcontract was let. The location and extent of each section and the subcontractor having the work in charge are as follows:

Section 1, from City Hall to Chambers St., the Degnon & McLean Construction Co.

Section 2, from Chambers St. to Great Jones St., the Degnon & McLean Construction Co.

Section 3, from Great Jones St. to 33d St., Messrs. Holbrook, Cabot & Daly.

Section 4, from 33d St. to 41st St., Mr. Ira Shaller.

Section 5a, from 41st St. to 47th St. and Broadway, the Degnon & McLean Construction Co.

Section 5b, from 47th St. to 61st St., Messrs. Naughton & Co.

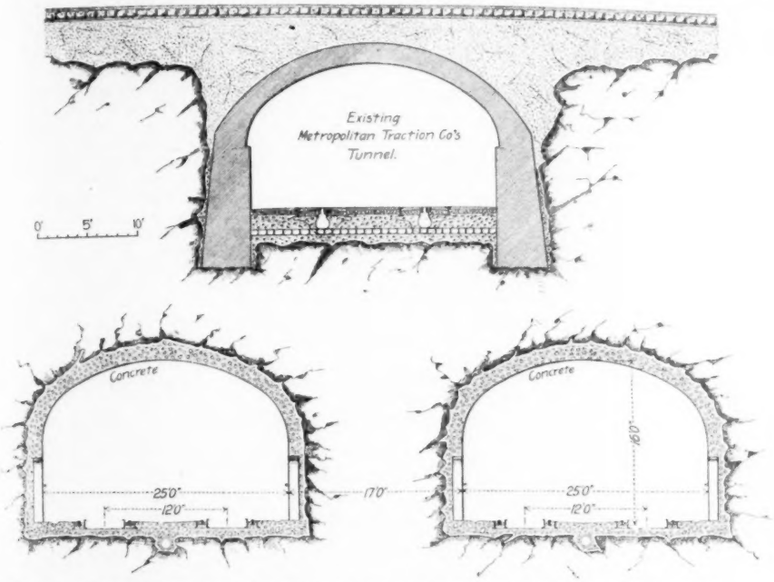


FIG. 6. FOUR-TRACK DOUBLE-TUNNEL CONSTRUCTION UNDER PARK AVENUE.

Section 6a, from 61st St to 82d St., Mr. William Bradley.

Section 6b, from 82d St. to 104th St., Mr. William Bradley.

Section 7, East Side Line, from 104th St. to 110th St., Messrs. Hopper & Farrell.

Section 8, East Side Line, from 110th St. to 131st St., Messrs. Hopper & Farrell.

Section 9, East Side Line, from 131st St. to 149th St. and Westchester Ave., Mr. J. C. Rogers.

Section 10, East Side Line, from 149th St. to terminus (elevated structure).

Section 11, from 104th St. to 125th St. and Broadway, Mr. John Shields.

Section 12, from 125th St. to 133d St. and Broadway (elevated structure).

Section 13, from 133d St. to 181st St., Messrs. L. B. McCabe & Brother.

Section 14, from 181st St. to Fort George, Messrs. L. B. McCabe & Brother.

Section 15, from Fort George to west terminal (elevated structure).

The subcontracts for the elevated structure have been let to E. P. Roberts for the foundations, to the American Bridge Co. for the steelwork, and to the Terry & Tench Construction Co. for the erection of the steelwork. The cement used is being furnished by contract by the United Building Material Co., of New York city, and the waterproofing employed in the subway lining is being furnished by the Sicilian Asphalt Co., of New York city.

BOOK REVIEWS.

ELECTRIC GAS LIGHTING.—How to Install Electric Gas Igniting Apparatus, including the Jump Spark and Multiple Systems. By H. S. Norrie. New York, 1901: Spon & Chamberlain. Cloth; 4½ × 6¼ ins.; pp. 97; 57 illustrations. 50 cts.

The title of this work gives a good idea of its contents. The different forms of apparatus used for igniting illuminating gas are described and their application is discussed. The methods of operating such devices singly or in multiple, by push-buttons, doors, etc., are explained and directions for wiring are given; hints as to selecting and installing the necessary coils and batteries are also included.

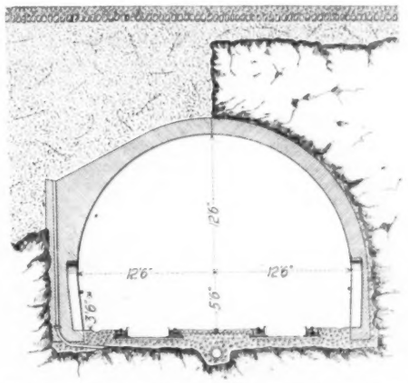


Fig. 7. Standard Earth and Rock Sections for Deep Tunnel Under Central Park.

NOTES ON THERMODYNAMICS.—By H. W. Spangler, Professor of Mechanical Engineering in the University of Pennsylvania. New York, 1901: John Wiley & Sons. Cloth; 4¾ × 7½ ins.; pp. 69; 24 illustrations. $1.00.

As explained in the preface to this book, it is a compilation of notes originally prepared by the author for use in his classes with the purpose of covering the theoretical side of thermodynamics more rapidly than could be done with the aid of previous books on the subject. Corresponding to this, it is a very condensed treatment of the behavior of gases, more especially of steam, under the varying influences of temperature and pressure. This condensed form is the main feature of the book; together with the necessary extended use of the calculus it makes the book seem not well adapted for self study or reference. It should be noted, however, that the preface distinctly recognizes this fact.

MECHANICAL DRAWING.—Written for the Use of Naval Cadets at the United States Naval Academy. By F. W. Bartlett, Lieutenant Commander U. S. Navy. New York: John Wiley & Sons. Cloth; 6 × 9 ins.; pp. 188; 132 illustrations. $3.

This book is perhaps best described as a manual on the technic of mechanical drafting which overlaps in some places the field of constructive mechanical drafting. It is intended for beginners and it is, therefore, elementary and

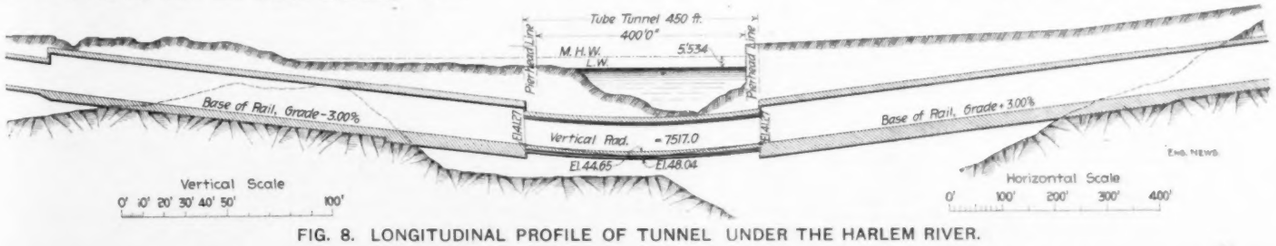


FIG. 8. LONGITUDINAL PROFILE OF TUNNEL UNDER THE HARLEM RIVER.

profuse in its presentation of the details of methods and workmanship. The text is lucidly written and the illustrations with a few exceptions are good. As examples of the poor drawings we may note those on pp. 43 and 52 as being crude in execution and inconvincing in their presentation of the point which they are designed to illustrate. In the drawing on p. 86 the standing indicates curved surfaces rather than receding plain surfaces. These faults would be trifling in a working drawing, but in a text book designed for the guidance of students they are

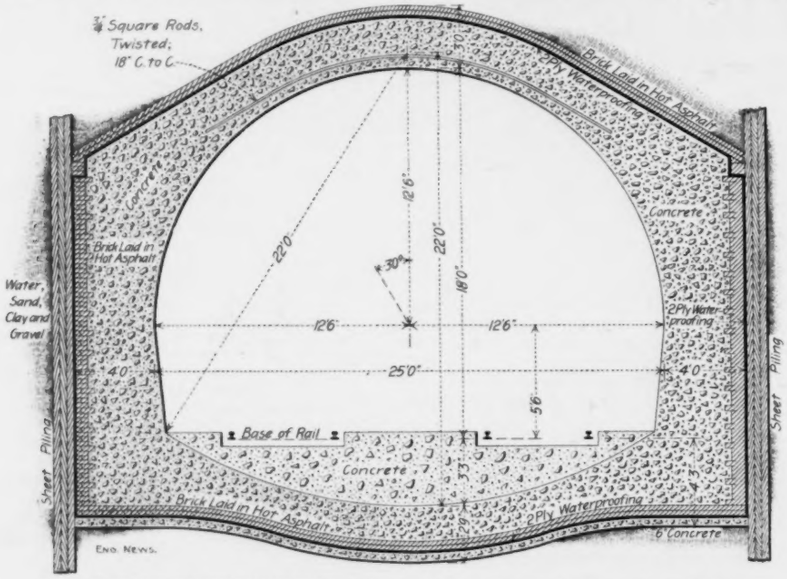


FIG. 9. SECTION OF DOUBLE-TRACK APPROACHES, HARLEM RIVER TUNNEL.

of importance. One feature of the book which will commend it to many is the fact that the methods described are based so far as was possible on the methods employed in the various engineering bureaus of the U. S. Navy Department.

AMERICAN MINES ANNUAL, Comprising a Careful, Accurate and Concise Compilation of the Active Gold, Silver, Copper, Lead and Zinc Mining and Milling Companies throughout the United States. Compiled by George E. Vigouroux, LL. B. Published by the Author, 1278 Broadway, New York City. 6 × 8 ins.; cloth; pp. 194. $5.

This book is a directory of active mining companies arranged alphabetically under the company names. The address of each company is given, together with its capital stock, the par value of its shares and the names of from one to four of its principal officers; in some cases a note or two is added relating to the kind of product or the size of mill or smelter. The author would have added much to the usefulness of his work if he had chosen a geographical instead of an alphabetical arrangement under names of companies, had used fewer abbreviations and given a little more information to show the scope of the various companies. As his book stands, the trifling little concerns which do not buy $5,000 worth of supplies in a year are hardly to be distinguished from the great companies whose annual purchases amount to millions of dollars. The author proposes to issue a revised edition annually; and we trust he will radically alter the general plan of his work another year.

OUTLINES OF ELECTRO-CHEMISTRY.—By Harry C. Jones, Assoc. Professor of Physical Chemistry at Johns Hopkins University. New York, 1901: The Electrical Review Publishing Co. Cloth.; 7 × 10 ins.; pp. 106; illustrated, $1.50.

This work is a reprint of a series of papers which appeared during the past year in the "Electrical Review" under the caption "Selected Chapters in Electro-Chemistry." As might be inferred from this, the book is to a great extent a historical account, presenting a progressive exposition of the elementary phases of this important subject. It introduces the reader—presumably the ordinary electrical or other engineer—to the extensive domain of physical chemistry, which, owing to its recent development, is entirely unknown to most engineers. Beginning with the work of Van't Hoff in 1887, the reader is led upward along the lines of investigation of Arrhenius and Ostwald, Nernst and others, and is made acquainted with the chief results of their labors in connection with the theory of solutions and electrolytic dissociation. In the concluding chapters the book shows how the theory is applied to voltaic cells and gives the methods of calculating the electromotive force developed by different types of primary cells.

Though the book is elementary and introductory in character throughout, it will doubtless prove highly interesting and instructive not only to electrical engineers, but also to others who appreciate the importance of electro-physical and electro-chemical manifestations.

FURNACE DRAFT: ITS PRODUCTION BY MECHANICAL METHODS. By William Wallace Christie, M. Am. Soc. M. E. Author "Chimney Design and Theory," etc. New York: D. Van Nostrand Co. Pamph. 4 × 6 ins.; pp. 44. Price, 50 cents.

This little book contains a variety of information on the subject of draft produced by chimneys, by steam jets, and by fans in both the forced and the induced draft systems. The author in his preface claims to be unbiased as far as any particular make of apparatus is concerned, and he certainly makes good his claim, for he shows up both the good and bad points of all the different systems. Much of the information is compiled from earlier publications, due credit being given, and as much of the earlier literature on the subject is very bad, it is not surprising that the author's selections are good, bad and indifferent. An example of a rather bad selection is the following:

Though there is much uncertainty as to just how much air is used in the burning of fuel, it is said that with forced draft 50% excess air is required in addition to the theoretical quantity, or a total of 18 lbs. of air per lb. of coal; when natural chimney draft is used 100% excess air or 24 lbs. per lb. of coal.

A more correct statement would be that with either forced or natural draft 50% excess air is "required" to insure complete combustion, but that the amount "used" varies from an actual deficiency, giving imperfect combustion, to an excess of 200% or more, according to the management of the fire.

Most of the book gives the impression that the author is not quite sure as to the relative merits of forced and chimney draft, but the last paragraph shows that he has reached the correct conclusion:

It would seem that for the majority of power steam plants, better returns (financially), would result from natural draft, produced not by any chimney, but by means of a chimney or chimneys designed especially for each plant.

In other words, a consulting engineer should be called in to design the chimney or chimneys for each case. The book contains several useful tables, and it is worth its price to any one interested in the subject.

ELEMENTARY COURSE OF INSTRUCTION FOR STATIONARY ENGINEERS.—By Floyd Davis, E.M., Ph. D., President of the Board of Examiners for State Mine Inspectors of Iowa. Published by the Western Correspondence School of Mining Engineering, Des Moines, Iowa, 1901. Cloth; 12mo.; pp. 88. $1.75.

ELEMENTARY COURSE OF INSTRUCTION FOR HOISTING AND SLOPE ENGINEERS. By the same author. Cloth; 12mo.; pp. 124. $2.75.

The scope of the first of these two books may be judged from the titles of its chapters and the number of pages in each, as follows: Arithmetic, 16; Mensuration, 8; Mechanics, 12; Mechanical terms and other information, 8; Firing steam boilers, 4; Impurities in water, 4; Boiler management and inspection, 4; Steam engines, 8; The steam engine indicator, 4; Questions for review, 11; Index, 3. The book is built on the catechism plan, with questions and answers, and it does not contain a single cut to explain its text. The amount of information it contains is extremely limited, considering the price of the book, and its quality is of every grade from middling good to very bad. It contains a few gems of engineering literature, among them the following, which is part of the answer to the question: "Name some practical points to consider in the operation of a steam engine?"

The force that does the work in an engine is the mean effective pressure of the steam in the cylinder, which an indicator shows is generally from 40 to 60% less than the boiler pressure, the loss being due to condensation, friction and atmospheric resistance. Under ordinary conditions the actual beneficial result to be utilized from the steam in the cylinder may thus be considered only about one-half of that shown by the water in the boiler. It is therefore evident that for every 30 lbs. of water evaporated each hour the engine, to be properly adjusted to it, should be required to use only about 15 lbs. of steam.

Under the head of "Impurities in Water," we find this ancient bit of misinformation:

It is estimated that 1-16-in. of scale causes a loss of 13% of fuel, ⅛-in. causes a loss of 38% of fuel, and ¼-in. causes a loss of 60% of fuel. In this manner an immense waste of fuel occurs with all dirty boilers.

Of still more antique flavor is the following:

In condensing engines the pressure is not usually greater than 45 lbs. per sq. in.

The second book contains 36 more pages, and costs $1 more than the first, but is an exact duplicate of the first, word for word, for its first 68 pages. It omits the chapter on the steam-engine indicator, and contains the following additional chapters: Hoisting and haulage engines, 4 pages; Other hoisting appliances, 4; Safety appliances, 4; Pumping machinery, 4; Underground transportation, 8; The compression of air, 4; Electricity in mining, 8. The questions for review in this book cover 15 pages. We give a few extracts from these chapters.

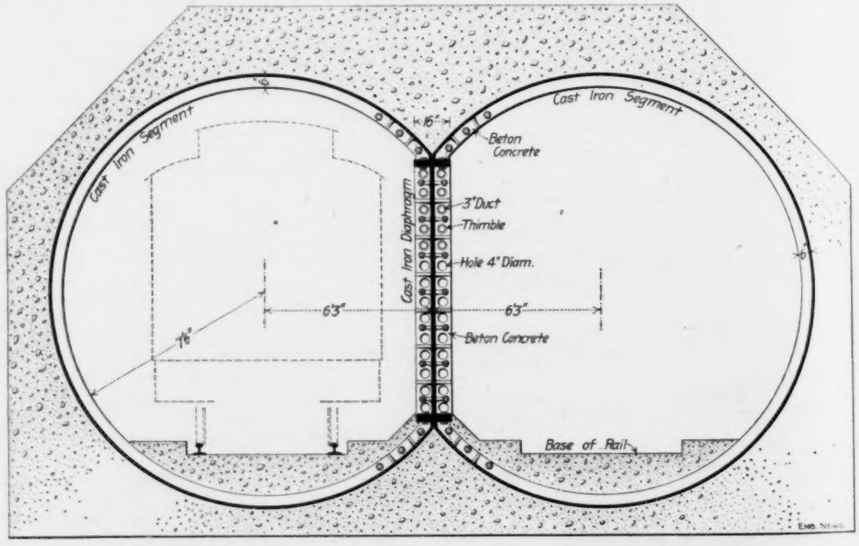


FIG. 10. SECTION OF DOUBLE TUNNEL UNDER CHANNEL OF HARLEM RIVER.

Too rapid hoisting is unnecessarily destructive, since the strain imparted to them [wire cables] is proportional to the square of the velocity with which they move.

Hoisting cables are now commonly of wire, but the relative economy of hemp and wire rope is still an open question where the conditions for hoisting are favorable.

In the description of a dynamo, it is said, p. 101, that a positive current is taken from one side and a negative from the other, and these direct currents are always in one direction when a commutator is used.